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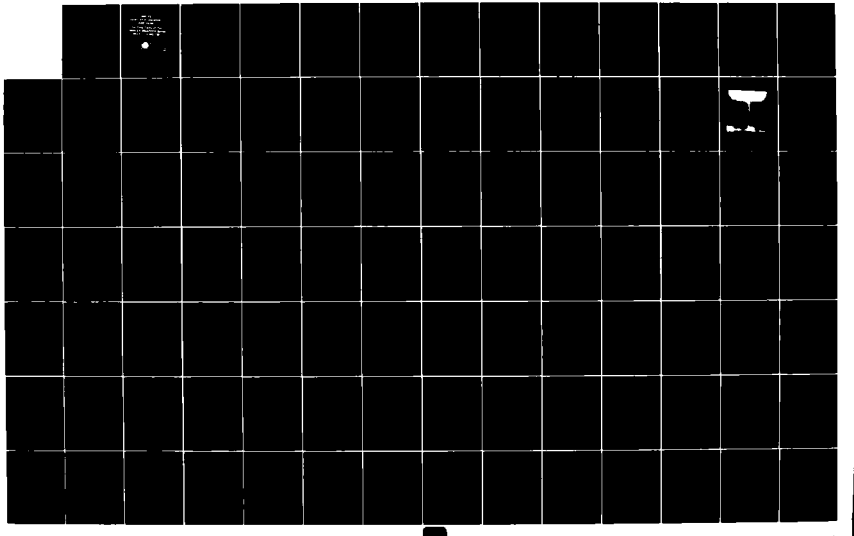

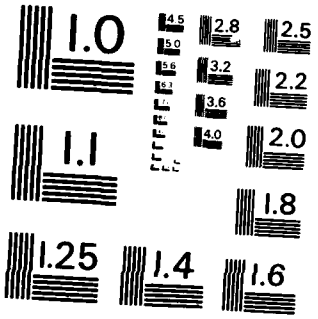

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SHOTS EASY, FOX, GEORGE, AND HOW

The Final Tests of the TUMBLER-SNAPPER Series 7 MAY - 5 JUNE 1952

United States Atmospheric Nuclear Weapons Tests
Nuclear Test Personnel Review

Prepared by the Defense Nuclear Agency as Executive Agency for the Department of Defense

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This report describes the activities of DOD personnel, both civilian and military, in Shots EASY, FOX, GEORGE, and HOW, the final Operation TUMBLER-SNAPPER shots, conducted from 7 May to 5 June 1952. These tests involved participants from Exercise Desert Rock IV, AFSWP, AFSWC, and an AEC nuclear weapons development laboratory. This volume also describes the radiological safety activities at each of these shots.

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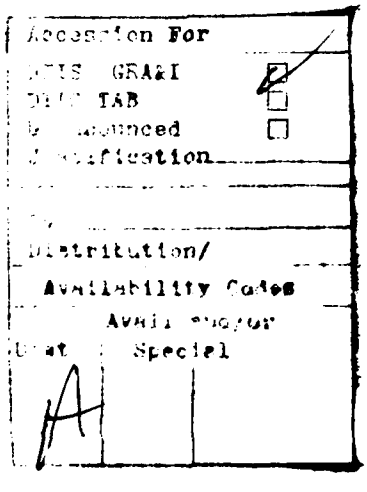

PREFACE

Between 1945 and 1962, the U.S. Government, through the Manhattan Engineer District and its successor agency, the Atomic Energy Commission (AEC), conducted 235 atmospheric nuclear weapons tests at sites in the United States and in the Atlantic and Pacific Oceans. In all, an estimated 220,000 Department of Defense (DOD) participants, both military and civilian, were present at the tests. Of these, approximately 90,000 participated in the atmospheric nuclear weapons tests conducted at the Nevada Proving Ground* (NPG), northwest of Las Vegas, Nevada.

In 1977, 15 years after the last above-ground weapons test, the Center for Disease Control+ noted a possible leukemia cluster among a small group of soldiers at Shot SMOKY, one weapons-related test of Operation PLUMBBOB, the Nevada test series conducted in 1957. Since that initial report by the Center for Disease Control, the Veterans Administration has received a number of claims for medical benefits from former military personnel who believe their health may have been affected by their participation in the weapons testing program.

In late 1977, the Department of Defense began a study to provide data to both the Center for Disease Control and the Veterans Administration on potential exposures to ionizing radiation among the military and civilian participants in atmospheric nuclear weapons testing. The DOD responded by organizing an effort to:

- Identify DOD personnel who had taken part in the atmospheric nuclear weapons tests

---

*Renamed the Nevada Test Site in 1955.

+The Center for Disease Control is an agency of the U.S. Department of Health and Human Services (formerly the U.S. Department of Health, Education, and Welfare).

- Determine the extent of the participants' exposure to ionizing radiation
- Provide public disclosure of information concerning participation by DOD personnel in the atmospheric nuclear weapons tests.

METHODS AND SOURCES USED TO PREPARE THIS VOLUME

This report on the final four nuclear events of Operation TUMBLER-SNAPPER is based on the military and technical documents associated with these atmospheric nuclear weapons tests. Many of the documents pertaining specifically to DOD involvement at Shots EASY, FOX, GEORGE, and HOW were found in the Defense Nuclear Agency Technical Library, the Office of Air Force History, and the Modern Military Branch of the National Archives.

In certain cases, the surviving historical documentation of activities conducted during Operation TUMBLER-SNAPPER addresses test specifications and technical information rather than the personnel data critical to the study undertaken by the Department of Defense. Moreover, these documents sometimes reveal inconsistencies in vital facts. Efforts have been made to resolve these inconsistencies wherever possible or to bring them to the attention of the reader.

In addition to these inconsistencies, the documents describing projects of the Armed Forces Special Weapons Project (AFSWP) do not always refer to project titles and agencies in the same way. To make this information as uniform as possible, this report uses weapons test report titles for each project. Information concerning the dates and yields of the test detonations is taken from the Department of Energy, Announced United States Nuclear Tests, July 1945 through 1979 (NVO-209). Other facts, such as meteorological conditions and dimensions of the clouds formed by the detonations, are taken from DNA 1251-1, Compilation of Local Fallout Data from Test Detonations 1945-1962, Volume 1, except in instances where more specific information is available elsewhere.

For several of the Exercise Desert Rock and test organization projects discussed in this volume, the only documents available are the Sixth Army Desert Rock operations orders and the Test Director's schedule of events from "Operation Order 1-52." These sources detail the plans developed by DOD and AEC personnel during Operation TUMBLER-SNAPPER, but it is not known if all the projects addressed in the planning documents were conducted exactly as planned. Although some of the after-action documents summarize the projects performed during Operation TUMBLER-SNAPPER, they do not always supply shot-specific information. In the absence of shot-specific after-action reports, projects are described in this volume according to the way they were planned. The references indicate whether the description of activities is based on the schedule of events, operation orders, or after-action reports.

ORGANIZATION AND CONTENT OF OPERATION TUMBLER-SNAPPER REPORTS

This volume details participation by DOD personnel in the last four events of the Operation TUMBLER-SNAPPER atmospheric nuclear weapons testing series. Two other publications address DOD activities during this series:

- Series volume: Operation TUMBLER-SNAPPER, 1952
- Multi-shot volume: Shots ABLE, BAKER, CHARLIE, and DOG, the First Tests of the TUMBLER-SNAPPER Series.

The volumes addressing the test events of Operation TUMBLER-SNAPPER are designed for use with one another. The series volume provides general information on topics such as the historical context of the TUMBLER-SNAPPER test program, its overall objectives, and the layout of the Nevada Proving Ground. In addition, the series volume contains a bibliography of works consulted in the preparation of all three Operation TUMBLER-SNAPPER reports. The multi-shot volumes do not contain this

general information. Instead, each multi-shot volume combines shot-specific descriptions of several nuclear events and presents a bibliography only of the sources referenced in the text. Descriptions of activities concerning any particular shot in Operation TUMBLER-SNAPPER may be supplemented by the general organizational and radiological safety information contained in the Operation TUMBLER-SNAPPER volume.

The first chapter of this volume describes the physical setting and general characteristics of Shots EASY, FOX, GEORGE, and HOW and briefly introduces the Desert Rock exercises and the joint AEC-DOD organization scientific activities in which DOD personnel participated. Desert Rock IV exercises were not conducted at Shots EASY and HOW. The remaining four chapters address each of the four shots in turn. Each chapter describes the specific setting and characteristics of one detonation and details DOD personnel activities in the scientific projects sponsored by the joint organization. In the chapters on FOX and GEORGE, Exercise Desert Rock IV activities are described. The chapters also discuss the radiological protection procedures used to minimize the potential for exposures to ionizing radiation. Details of the overall radiological protection program at Operation TUMBLER-SNAPPER are provided in the series volume.

The information in this report is supplemented by the Reference Manual: Background Materials for the CONUS Volumes. The manual summarizes information on radiation physics, radiation health concepts, exposure criteria, and measurement techniques. It also has a list of acronyms and a glossary of terms used in the DOD reports addressing test events in the continental United States.

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LIST OF ABBREVIATIONS AND ACRONYMS

The following abbreviations and acronyms are used in this volume:

AEC	Atomic Energy Commission
AFB	Air Force Base
AFSWC	Air Force Special Weapons Center
AFSWP	Armed Forces Special Weapons Project
BJY	BUSTER-JANGLE Y
CBR	Chemical, Biological, and Radiological
DOD	Department of Defense
EG&G	Edgerton, Germeshausen, and Grier, Inc.
HumRRO	Human Resources Research Office
IBDA	Indirect Bomb Damage Assessment
LASL	Los Alamos Scientific Laboratory
NPG	Nevada Proving Ground
ORO	Operations Research Office
R/h	Roentgens per hour
SAC	Strategic Air Command
UCLA	University of California at Los Angeles
UTM	Universal Transverse Mercator

CHAPTER 1

INTRODUCTION

Shots EASY, FOX, GEORGE, and HOW were tests of nuclear devices conducted from 7 May to 5 June 1952 at the Nevada Proving Ground, the continental test site northwest of Las Vegas. The shots were the final four detonations of Operation TUMBLER-SNAPPER, the atmospheric nuclear weapons tests conducted from 1 April to 5 June 1952. Shots EASY, FOX, GEORGE, and HOW were all detonated from 300-foot* towers (62; 67).+

The Los Alamos Scientific Laboratory (LASL), an AEC nuclear weapons development laboratory, designed and built these four nuclear devices. All four shots were part of the SNAPPER phase of Operation TUMBLER-SNAPPER. They were weapons development studies, intended to test weapons for the nuclear stockpile and to study techniques to be used during Operation IVY, scheduled for the fall of 1952 (62; 67).

Table 1-1 presents data on Shots EASY, FOX, GEORGE, and HOW. It includes such information as the UTM** coordinates of the points of detonation and the heights of burst. Figure 1-1 displays a 1952 map of the Nevada Proving Ground, with the positions of each TUMBLER-SNAPPER test (62).

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*In this report, vertical distances are expressed in feet. Altitudes are usually stated from mean sea level, while heights are measured from the surface.

+All sources cited in the text are listed alphabetically and numbered in the Reference List at the end of this volume. The number given in the text is the number of the source document in the Reference List.

**Universal Transverse Mercator (UTM) coordinates are used in this report. The first three digits refer to a point on an east-west axis, and the second three refer to a point on a north-south axis. The point so designated is the southwest corner of an area 100 meters square.

Table 1-1: SUMMARY OF THE FINAL FOUR OPERATION TUMBLER-SNAPPER EVENTS (1952)

Shot	EASY	FOX	GEORGE	HOW
Sponsor	LASL	LASL	LASL	LASL
Planned Date	6 May	13 May	20 May	27 May
Actual Date	7 May	25 May	1 June	5 June
Time*	0415	0400	0355	0355
NPG Location	Area 1	Area 4	Area 3	Area 2
UTM Coordinates	798009	795056	871004	784104
Type of Detonation	Tower	Tower	Tower	Tower
Height of Burst (feet above terrain)	300	300	300	300
Yield (kilotons)	12	11	15	14

* Pacific Standard Time is used throughout this report for reasons of consistency. Although Pacific Daylight Time came into effect on 27 April 1952, many of the source documents continued to use Pacific Standard Time.

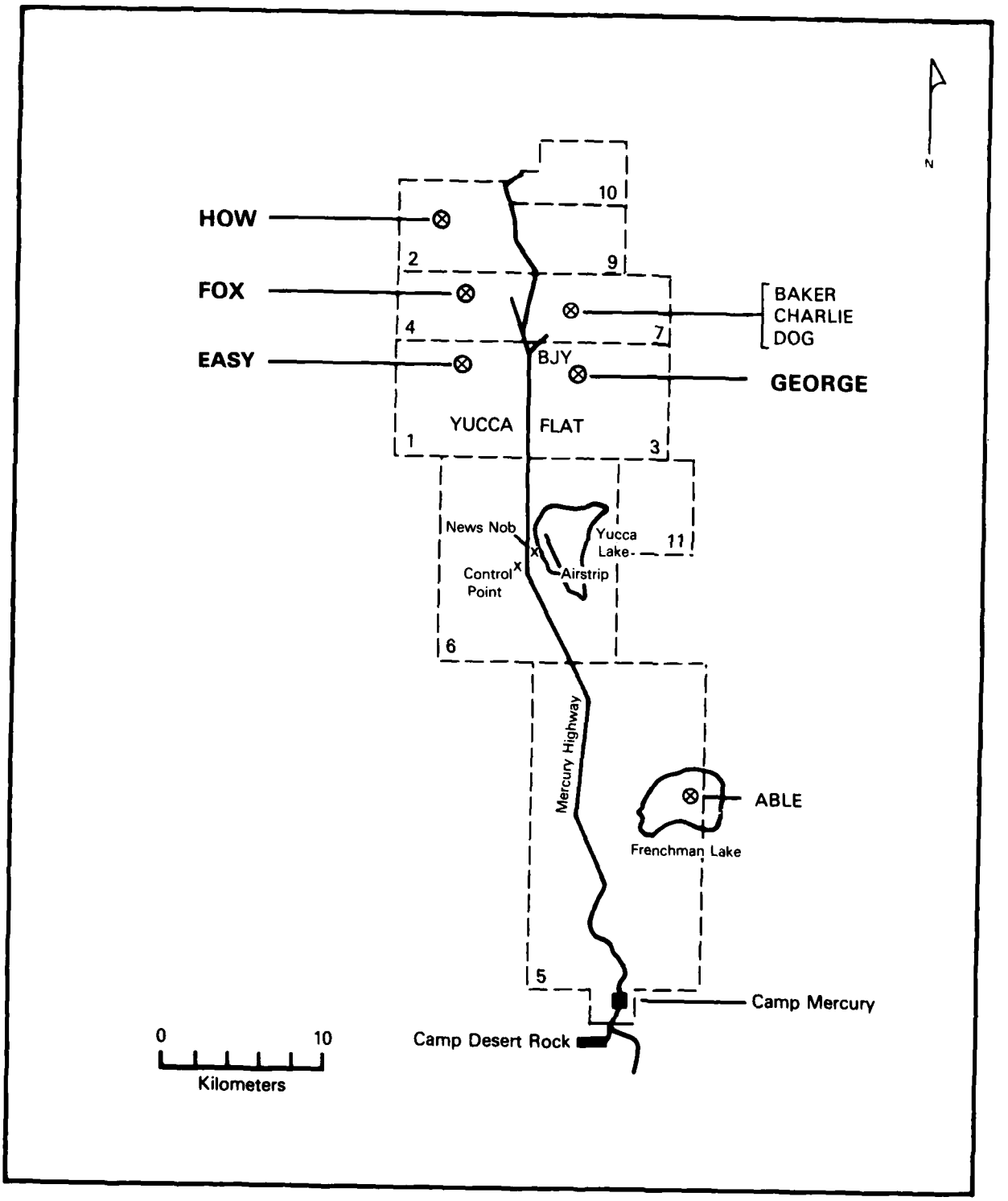


Figure 1-1: LOCATION OF SHOTS EASY, FOX, GEORGE, AND HOW AT THE NEVADA PROVING GROUND IN RELATION TO OTHER SHOTS IN THE TUMBLER-SNAPPER SERIES

1.1 DEPARTMENT OF DEFENSE PARTICIPATION AT THE FINAL FOUR TUMBLER-SNAPPER EVENTS

The joint AEC-DOD organization was established to plan, coordinate, and conduct atmospheric nuclear weapons tests during Operation TUMBLER-SNAPPER. Composed of personnel from the Atomic Energy Commission and the Department of Defense, the joint AEC-DOD organization included representatives of various weapons development laboratories, AFSWP Test Command, and AFSWC. The many scientific and diagnostic projects conducted at the final four TUMBLER-SNAPPER events were fielded by two test groups and coordinated by the joint AEC-DOD organization. Other activities were conducted as part of the military training programs associated with Exercise Desert Rock IV. These activities, planned and conducted by the armed services, were reviewed and approved by the Test Manager to ensure coordination with the AEC and the test groups.

Department of Defense participation at Shots EASY through HOW was in four general areas:

- Administrative and support services for the joint AEC-DOD organization
- Test group scientific and diagnostic activities, especially those of AFSWP
- Exercise Desert Rock IV military maneuvers and support
- Air support.

Although the AEC was responsible for planning, coordinating, and executing the programs and activities associated with Operation TUMBLER-SNAPPER, DOD personnel assisted the AEC Test Manager in these duties. The DOD personnel attached to the joint AEC-DOD organization were responsible for overseeing DOD's technical and military planning objectives.

DOD personnel also participated in the scientific and diagnostic projects conducted by two test groups: the Military

Effects Test Group, directed by Test Command, AFSWP, and the Weapons Development Test Group, with scientists from the Los Alamos Scientific Laboratory, from Edgerton, Germeshausen, and Grier, Inc. (EG&G), from the Naval Research Laboratory, and from the Sandia Corporation. The Military Effects Test Group involved more DOD participants than did the other test group. Drawn from various DOD civilian and military laboratories, these participants conducted experiments to learn more about weapons effects. Activities of the AEC Weapons Development Test Group were conducted primarily by the Los Alamos Scientific Laboratory. However, some DOD personnel were assigned to LASL and participated in its experiments.

Participants in test group projects generally placed instruments and experimental material around the intended ground zero in the days and weeks before the scheduled detonation. After the detonation, when the Test Manager had determined that the radiological environment in the shot area would permit access, they returned to recover the equipment. During a detonation, project personnel were generally positioned at designated observer locations or were operating equipment or aircraft at substantial distances from ground zero.

Military training maneuvers involving DOD personnel were conducted through the Exercise Desert Rock IV programs at Shots FOX and GEORGE. The Desert Rock IV programs usually involved more DOD participants than did the test group projects. Desert Rock activities generally included orientation and indoctrination programs, highlighted by the observation of a nuclear burst. At Shot GEORGE, Exercise Desert Rock IV also included tactical troop maneuvers after the detonation.

Approximately 1,500 soldiers from various Army units provided support for the Exercise Desert Rock programs. They maintained and operated Camp Desert Rock, an installation of the

Sixth Army. These soldiers provided essential services, such as food and housing, as well as transportation, communications, construction, and security support. Some of the Desert Rock support troops worked in the forward areas of the NPG to construct observer trenches, lay communication lines, provide transportation, and assist with other preparations for Desert Rock IV activities. Many of the Camp Desert Rock support personnel observed at least one detonation during Operation TUMBLER-SNAPPER, and some were called upon to perform support or staff duties in the test areas during nuclear detonations.

Finally, DOD personnel provided air support for the Test Manager and the test groups. The Air Force Special Weapons Center provided air support to the Test Manager. AFSWC conducted cloud sampling, sample courier missions, cloud tracking, aerial radiation surveys of the terrain, and other air support as requested. AFSWC consisted of units of the 4925th Test Group (Atomic) and the 4901st Support Wing (Atomic). Units from the 4925th Test Group and 4901st Support Wing from Kirtland AFB staged out of Indian Springs AFB, 30 kilometers* east of Camp Mercury.

1.2 DEPARTMENT OF DEFENSE INVOLVEMENT IN JOINT AEC-DOD ORGANIZATION ACTIVITIES AT THE FINAL FOUR TUMBLER-SNAPPER EVENTS

The Military Effects Test Group and the Weapons Development Test Group conducted scientific and diagnostic projects at Shots EASY, FOX, GEORGE, and HOW. Information on the numbers of participants in the test group projects and the times of their activities has been obtained from the Test Director's "Operation

*Throughout this report, surface distances are given in metric units. The metric conversion factors include: 1 meter = 3.28 feet; 1 meter = 1.09 yards; 1 kilometer = 0.62 miles.

Order 1-52" for the four shots (63). This document gives plans developed by DOD and AEC personnel before each TUMBLER-SNAPPER shot, but it does not describe the projects as actually conducted. In many instances, no documentation has been found that indicates whether or not the recovery times and numbers of personnel mentioned in project plans were the times and numbers in the actual tests. The description of test group activities in the following chapters assumes that projects were performed to specifications given in the "Operation Order 1-52."

Department of Defense participants followed radiological protection procedures established by the joint AEC-DOD organization and AFSWC. These procedures, described in the Operation TUMBLER-SNAPPER volume, were designed to minimize exposure to ionizing radiation. Documents differ as to the exposure limit for test group participants. The radiological safety report indicates that 3.9 roentgens was the limit (43), but other planning and after-action reports give the limit as 3.0 roentgens. AFSWC sampling pilots, however, were authorized to receive up to 3.9 roentgens during the series (36).

To implement the safety criteria, the AFSWP Radiological Safety Group controlled access to radioactive areas, and radiological safety monitors accompanied project personnel recovering test instruments from radioactive areas. The monitors, who continuously measured the radiation intensity in the recovery area, kept the participants informed of the radiological environment. To monitor cumulative exposures, project personnel were issued film badges. These film badges were collected, developed, and evaluated at regular intervals, and any individual whose cumulative exposure exceeded the established limits was barred from further participation in project activities conducted in the forward area. Personnel decontamination procedures were implemented, and emergency evacuation plans were prepared for all test events.

Complete decontamination, including showering and changing into clean clothing, was required of cloud-sampling personnel who were in the aircraft during each project mission, regardless of the exposure received on the flight. Other aircrew members underwent decontamination as necessary. Aircraft were either decontaminated by washing or were isolated until radiation intensities decayed to predetermined levels.

1.3 EXERCISE DESERT ROCK IV ACTIVITIES AT THE FINAL FOUR TUMBLER-SNAPPER EVENTS

Exercise Desert Rock IV was part of the Armed Forces' continuing program to train personnel in the use and effects of nuclear weapons and to test battlefield doctrine and tactics during the continental nuclear weapons tests. At Shot EASY, 1,000 Camp Desert Rock support personnel viewed the detonation from the vicinity of the Control Point. The majority of DOD personnel involved in Shots FOX and GEORGE were participants in two Desert Rock IV programs:

- The observer program, which involved watching a nuclear detonation, engaged a total of 1,950 DOD personnel at FOX.
- The tactical troop maneuver, which engaged troops after they had witnessed the detonation, involved 1,300 participants at GEORGE.

In addition, Camp Desert Rock support troops provided communication, transportation, traffic control, and radiological safety monitoring for Desert Rock projects at FOX and GEORGE.

Radiation protection procedures of Exercise Desert Rock IV, like those of the test groups and AFSWC, are detailed in the Operation TUMBLER-SNAPPER volume. Camp Desert Rock personnel and exercise participants were limited to 3.0 roentgens of exposure during Exercise Desert Rock IV. The radiation protection

procedures of Exercise Desert Rock IV included provisions for (4; 6; 25; 36; 43):

- Maintaining minimum safe distances from nuclear detonations
- Controlling access to radiation areas
- Issuing film badges to Desert Rock personnel
- Monitoring individuals working in radiation areas
- Monitoring the cumulative doses of personnel
- Decontaminating personnel and equipment
- Establishing emergency evacuation plans similar to those formulated by the test groups and AFSWC.

These procedures were intended to minimize exposure while allowing Desert Rock personnel to accomplish their missions. The Exercise Desert Rock IV radiation protection procedures are described in more detail in the Operation TUMBLER-SNAPPER volume.

SHOT EASY SYNOPSIS

AEC TEST SERIES:	TUMBLER-SNAPPER
DOD EXERCISE:	None
DATE/TIME:	7 May 1952, 0415 hours
YIELD:	12 kilotons
HEIGHT OF BURST:	300 feet (tower)

DOD Objective: To determine the military value of weapons effects for offensive and defensive deployment.

Weather: At shot-time, the surface winds were calm. Winds were 36 knots from the south at 10,000 feet, 67 knots from the southwest at 20,000 feet, and 93 knots from the southwest at 30,000 feet. The temperature was 16°C, the relative humidity was 40 percent, and the pressure was 868 millibars.

Radiation Data: Onsite residual radioactivity was heaviest around and to the north of ground zero. The initial survey team was unable to complete the survey on shot-day because of the large radiation area and the rough terrain. On the day after the shot, the 0.01 R/h line was located about 1,000 meters east, south, and west of ground zero but extended offsite to the north of ground zero.

Participants: Exercise Desert Rock IV participants; Los Alamos Scientific Laboratory; Armed Forces Special Weapons Project; Atomic Energy Commission; Air Force Special Weapons Center; contractors.

CHAPTER 2

SHOT EASY

Shot EASY, the fifth event of Operation TUMBLER-SNAPPER, was detonated at 0415 hours Pacific Standard Time on 7 May 1952. The first detonation to be part of only the SNAPPER phase of Operation TUMBLER-SNAPPER, Shot EASY was a weapons development test. The shot had originally been planned for 6 May, but it was postponed for one day because of adverse weather. Developed by the Los Alamos Scientific Laboratory, the nuclear device was fired on a 300-foot tower in Area 1 of Yucca Flat, UTM coordinates 798009. Figure 2-1 shows the type of shot-tower used for Shot EASY and the other TUMBLER-SNAPPER tower detonations. EASY had a yield of 12 kilotons. The top of the Shot EASY cloud reached a height of 34,000 feet and moved northeast from the point of detonation (7; 30; 40; 67).

2.1 EXERCISE DESERT ROCK IV OPERATIONS AT SHOT EASY

There were no official Desert Rock IV exercises at Shot EASY. However, about 1,000 Camp Desert Rock support personnel viewed the detonation from the vicinity of the Control Point at Yucca Pass (15).

2.2 DEPARTMENT OF DEFENSE PARTICIPATION IN SCIENTIFIC AND SUPPORT ACTIVITIES AT SHOT EASY

Department of Defense personnel took part in scientific and diagnostic experiments conducted by the Military Effects Test Group and the Weapons Development Test Group. Table 2-1 lists the test group projects and identifies the participating organizations. In addition to the DOD personnel participating in test group experiments, AFSWC personnel provided air support to the test groups and to the Test Manager (24).

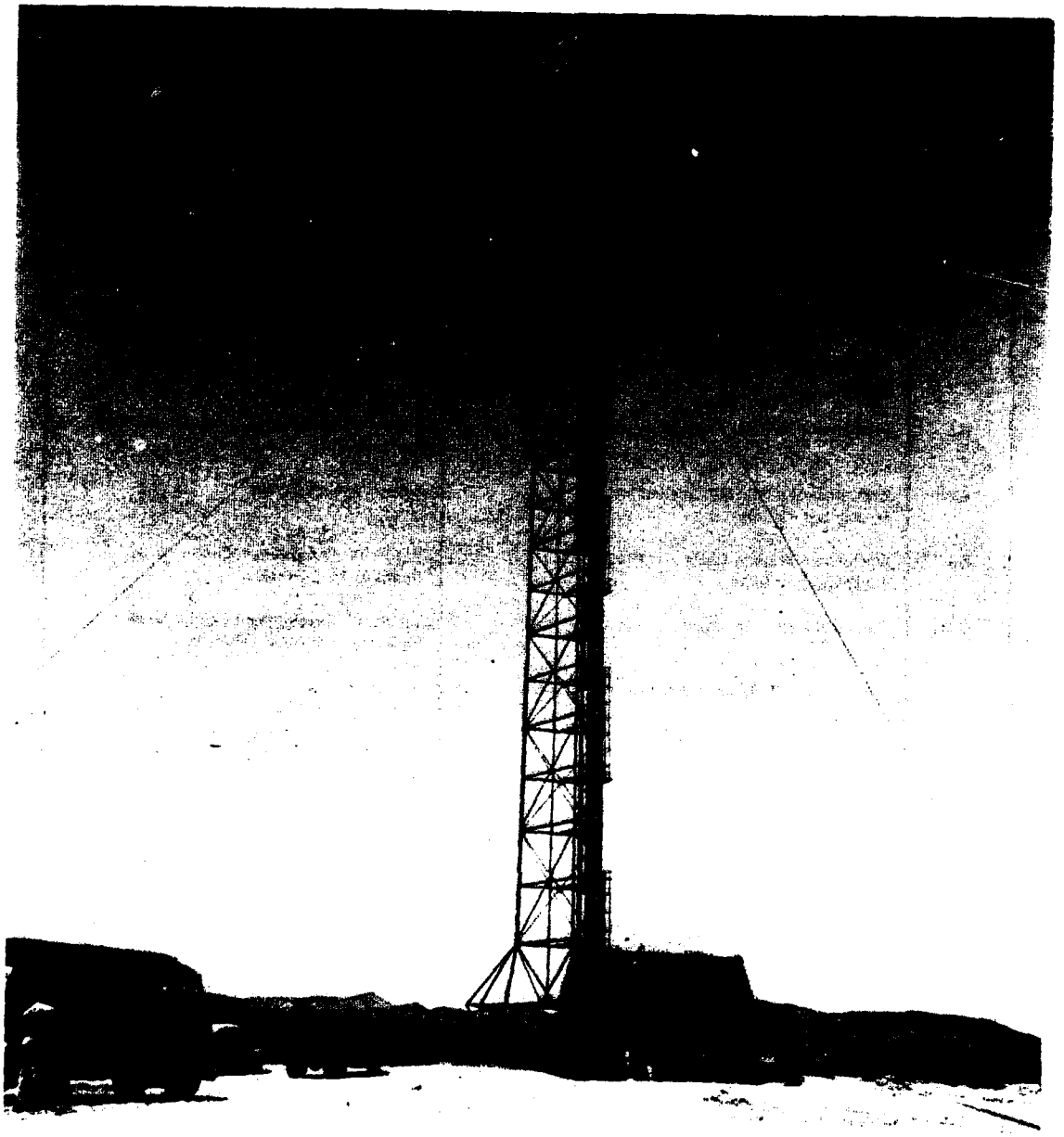


Figure 2-1: ONE OF THE 300-FOOT SHOT TOWERS USED DURING THE TUMBLER-SNAPPER SERIES

Table 2-1: TEST GROUP ACTIVITIES WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT EASY

Project/ Program	Title	Participants
	Military Effects Test Group	
1.1	Measurement of Free-air Atomic Blast Pressures	Air Force Cambridge Research Center; Rome Air Development Center
2.1	Total Gamma Exposure versus Distance	Signal Corps Engineering Laboratories
2.2	Gamma Ray Energy Spectrum of Residual Contamination	Signal Corps Engineering Laboratories
4.2	Biomedical Exposure Equipment	Naval Medical Research Institute
4.4	Gamma Depth Dose Measurement in Unit Density Material	Naval Medical Research Institute
6.1	Evaluation of Military Radiac Equipment	Bureau of Ships; Signal Corps Engineering Laboratories
6.3	Evaluation of a Filtration System for Pressurized Aircraft	Army Chemical Center
6.4	Operational Tests of Radar and Photographic Techniques for IBDA	Wright Air Development Center; Strategic Air Command
6.5	Decontamination of Aircraft	Wright Air Development Center; Naval Radiological Defense Laboratory
7.1a	Electromagnetic Effects from Atomic Explosions	National Bureau of Standards; Air Force Cambridge Research Center; Air Weather Service; Geophysical Laboratory of the University of California at Los Angeles
7.1b	Long Range Light Measurements	EG&G; Headquarters, Air Force
7.2	Detection of Airborne Low-frequency Sound from Atomic Explosions	Headquarters, Air Force; Signal Corps Engineering Laboratories; National Bureau of Standards
7.3	Radiochemical and Physical Analysis of Atomic Bomb Debris	Headquarters, Air Force
7.4	Seismic Waves from A-Bombs Detonated over a Desert Valley	Air Force 1009th Special Weapons Squadron; Coast and Geodetic Survey
9.1	Technical and Training Photography	Naval Medical Research Institute; Air Force Lookout Mountain Laboratory; Army Pictorial Service Division; Wright Air Development Center; 4925th Test Group (Atomic); SAC 5th and 28th Reconnaissance Technical Squadrons; Signal Corps Engineering Laboratories
9.2	Air Weather Service Participation	Air Weather Service
9.4	Effects of Atomic Explosions on the Ionosphere	Signal Corps Engineering Laboratories; 9471st Technical Service Unit
9.5	Electromagnetic Radiation over the Radio Spectrum from Nuclear Detonations	Signal Corps Engineering Laboratories; 9467th Technical Service Unit

Table 2-1: TEST GROUP ACTIVITIES WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT EASY (CONTINUED)

Project/ Program	Title	Participants
	Weapons Development Test Group	
10.1	Measurement of Alpha	Naval Research Laboratory
11.1	Measurement of Transit Time	Naval Research Laboratory
12.1	Technical Photography	EG&G
12.1c	Bhangmeter Mod II	EG&G
12.2a-d	High-speed Photography	Los Alamos Scientific Laboratory; EG&G
13	Radiochemistry Sampling Program	4925th Test Group (Atomic)
15.2	Gamma Radiation Exposure as a Function of Distance	Los Alamos Scientific Laboratory
17.1 and 17.2	External Neutron Measurements	Los Alamos Scientific Laboratory
18.1	Total Thermal Radiation and Atmospheric Transmission	Naval Research Laboratory
18.3	Color Temperatures	Naval Research Laboratory
18.4	High-resolution Spectroscopy	Naval Research Laboratory
19.1c-d	Shock-gauge Evaluations Tests	Sandia Laboratory; Los Alamos Scientific Laboratory
19.1e	Air Shock Pressures as Affected by Hills and Dales	Sandia Corporation
19.2a-b	Blast-wave Material Velocity Measurements	Los Alamos Scientific Laboratory; EG&G

2.2.1 Military Effects Test Group Projects

At Shot EASY, the Military Effects Test Group conducted a number of scientific projects. Figure 2-2 shows the instrument layout for these projects. The following project descriptions often discuss recovery operations as occurring after the announcement of recovery hour. Recovery hour was usually announced about an hour after the detonation, but for Shot EASY, the actual time of recovery hour is not known. However, it was reported that recovery parties were delayed several hours or rescheduled for entry on subsequent days because of the high radiation levels (43).

Project 1.1, Measurement of Free-air Atomic Blast Pressures, was conducted by the Air Force Cambridge Research Center, with support from the Rome Air Development Center. The objective was to measure the pressures produced by a nuclear detonation over a wide range of altitudes and distances (46).

At 2000 hours on the night before the detonation, one project participant traveled to a telemetry station 13 kilometers from ground zero, near the Control Point. He remained at the station through the detonation. Three other personnel went to locations east and south of ground zero to check instruments used to track the position of canisters that would be airdropped. They remained in the area for four hours.

At 2200 hours, the following activities began (46; 63):

- Two participants checked instruments for the tracking system, about three kilometers from ground zero. They returned to the Control Point within two hours.
- Two individuals checked the tracking beacon eight kilometers southwest of ground zero. They remained there for three hours and then traveled to one of the two manned tracking stations 11 kilometers south-southeast of ground zero.

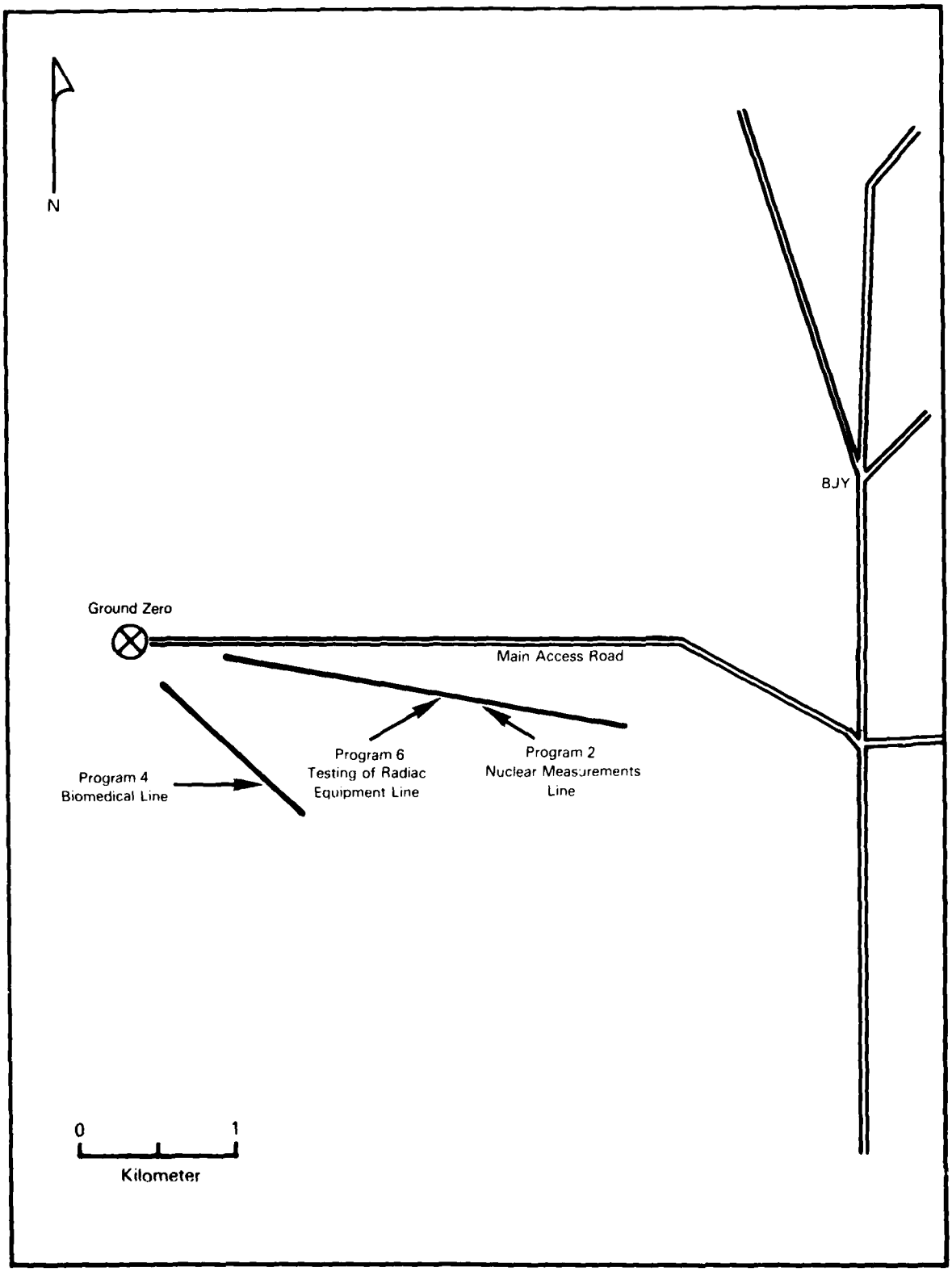


Figure 2-2: GROUND ZERO AND MILITARY EFFECTS TEST GROUP INSTRUMENT LAYOUTS AT SHOT EASY

- Four project personnel manned the other tracking stations, 11 kilometers east of ground zero. They operated the stations through shot-time and then returned to the Control Point.

- Fourteen participants proceeded to a telemetry station 730 meters north of the Control Point to check instruments. They remained there through shot-time.

- Three individuals traveled to the radar tracking station 11 kilometers south-southeast of ground zero to check instruments. They also remained there through shot-time.

- Fourteen project personnel traveled to the radar tracking station 11 kilometers south-southeast of ground zero. They remained at the station through shot-time to guide the two B-29s over the drop point.

Four hours before the detonation, two B-29s began calibration runs over ground zero. The aircraft, which staged from Kirtland AFB, New Mexico, were from the 6531st Flight Test Squadron of the Rome Air Development Center. The aircraft dropped the instrumented canisters about one minute before the detonation. The following list details the activities of these two B-29 aircraft (73):

SERIAL NUMBER	TAKEOFF TIME	ARRIVED SHOT AREA	DEPARTED SHOT AREA	LANDING TIME
1742	2221	0119	0422	0634
1863	2250	0132	0424	0625

Forty-five minutes after the announcement of recovery hour, two Project 9.1 participants photographed Project 1.1 activities. They remained in the shot area for three hours, approaching as close as five kilometers to ground zero. At 0900 hours on the day after the shot, ten men, traveling in four vehicles and a

helicopter, were scheduled to begin locating the canisters dropped in the area east-northeast of ground zero. Three days were allotted for this activity (46; 63; 73).

Project 2.1, Total Gamma Exposure versus Distance, was conducted by the Signal Corps Engineering Laboratories. The objective was to measure gamma radiation exposure as related to distance. Shortly before the detonation, project personnel placed film packets at 90-meter intervals between 610 and 2,750 meters east of ground zero. Three hours after the Test Manager opened the area for recovery operations, four personnel and a radiological safety monitor drove by truck into the shot area to retrieve film. They spent about three hours in this activity (57; 63).

Project 2.2, Gamma Ray E ergy Spectrum of Residual Contamination, was conducted by the Signal Corps Engineering Laboratories. The objective was to determine the relative dose contribution of various gamma radiation energies in contaminated areas after a nuclear detonation. To perform this experiment, personnel used radiation survey meters modified to shield portions of the gamma ray energy spectrum.

Before each shot, personnel calibrated five AN/PDR-T1B radiac instruments. After the Test Manager announced recovery hour, participants entered the shot area and placed the instruments on wooden tripods facing ground zero. They took the first radiac reading four hours after the detonation at 1,370 meters from ground zero. The intensity was 0.014 R/h. Personnel then moved their instruments to 1,050 meters from ground zero and took another reading a few minutes later. The intensity there was 0.145 R/h. A third reading was taken 730 meters from ground zero four hours and 19 minutes after the detonation, when the intensity was 1.2 R/h. The last reading of the day, 0.008 R/h, was taken 1,690 meters from ground zero four hours and 25 minutes

after the burst. The next day, participants took readings at distances of 1,800, 1,600, 1,500, and 1,100 meters from ground zero. At the conclusion of the field work, they dismantled equipment and returned to Camp Mercury to analyze the data (63; 77).

Project 4.2, Biomedical Exposure Equipment, was conducted by the Naval Medical Research Institute to measure blast and radiation effects on animals. To measure exposure to direct air blast, personnel instrumented wood models of dogs with accelerometers and then placed them in containers fitted with pressure recorders. Before the detonation, they placed the containers 340, 430, and 640 meters from ground zero. They also placed two movie cameras in the shot area to record the displacement of the containers by the blast wave. About four hours after the declaration of recovery hour, three project participants began recovering film from the cameras, a process that took about two hours.

To measure radiation effects, participants placed dosimeters in mouse cages located at distances of 90 to 180 meters from ground zero. Recovery personnel found that the cages had been destroyed by excessive blast pressure (34; 63).

Project 4.4, Gamma Depth Dose Measurement in Unit Density Material, was performed by the Naval Medical Research Institute. The experiment was designed to improve techniques used to evaluate biological effects of radiation on living tissue, particularly of the human body. To measure initial and residual gamma doses, participants placed dosimeters inside lucite spheres, which approximated the density of human tissue. Before the detonation, personnel placed lucite spheres of various wall thicknesses on A-frames located approximately 1,010 to 1,550 meters southeast of ground zero. After the declaration of recovery hour, seven personnel in a weapons carrier and a pickup truck spent about one hour retrieving the spheres (22; 63).

Project 6.1, Evaluation of Military Radiac Equipment, was conducted by the Bureau of Ships and the Signal Corps Engineering Laboratories to evaluate radiac survey equipment. Before the shot, project personnel placed dosimeters 910 to 2,740 meters east of ground zero. Three hours after the announcement of recovery hour, six personnel began recovering the dosimeters, an activity that took three hours. In addition, Project 6.1 personnel furnished standard and experimental radiation survey instruments to other projects so that the instruments could be evaluated (63; 72).

Project 6.3, Evaluation of a Filtration System for Pressurized Aircraft, was conducted by the Army Chemical Center. The objective was to determine the adequacy of a system for filtering particulate airborne fission products from the cabin air supply of an AFSWC B-29 sampler aircraft from the 4925th Test Group (Atomic) (66).

The B-29 had penetrated the cloud three times at altitudes between 32,000 and 33,000 feet. After the aircraft returned to Indian Springs AFB, project personnel removed equipment used to sample the influent and effluent from the air filter. They sealed these samples in clear film and then placed them in plastic bags, which were packed in wooden boxes and shipped to the Army Chemical Center for analysis. A B-25 courier aircraft left with the samples within about six hours of the detonation.

The filter used in the pressurization system was not removed for at least 24 hours to reduce the potential radiation exposure of the removal team. After the filter was removed, it too was packaged for shipment to the Army Chemical Center. Cloud sampling and courier flights are both discussed in section 2.2.3, on AFSWC activities at EASY (63; 66).

Project 6.4, Operational Tests of Radar and Photographic Techniques for IBDA, was conducted by the Wright Air Development Center, assisted by the Strategic Air Command (SAC). The objective was to evaluate the Indirect Bomb Damage Assessment (IBDA) system under development at the Wright Air Development Center. The 509th Bombardment Group of SAC provided three B-50D aircraft to make a postshot test of the IBDA system. The following listing summarizes the flight times for the aircraft, which staged from Kirtland AFB (18; 36):

AIRCRAFT	DEPARTURE TIME	LANDING TIME
B-50	0045	1045
B-50	0105	0635
B-50	0127	0845

At shot-time, the three aircraft, flying at altitudes of 25,000, 26,000, and 30,000 feet, were more than six kilometers south of the shot-tower, with cameras pointed toward the burst (18; 36).

Project 6.5, Decontamination of Aircraft, was conducted by the Wright Air Development Center and by the Naval Radiological Defense Laboratory. The project was designed to investigate methods of reducing radiation exposure to maintenance and flight crews.

To study adhesion of contamination to differently treated surfaces, project personnel treated various parts of two T-33 and one F-84G sampling aircraft with acid, polish, oil, or a combination of the three. These aircraft conducted the cloud sampling described in section 2.2.3. Five Air Force personnel, wearing protective clothing, film badges, and pocket dosimeters,

surveyed each aircraft immediately upon its landing. Using AN/PDR-T1B instruments, they surveyed radiation intensities at 32 locations on the aircraft before and after decontamination. Aircraft were considered decontaminated when all intensities were less than 0.02 R/h.

In the second part of this project, personnel monitored beta radiation on various parts of the same three aircraft. They used the USNRDL Mark V Model I beta radiation monitor to determine the distribution of beta-emitting contamination on these aircraft before and after decontamination.

For the third part of this project, participants measured radiation levels inside the cockpit of the F-84G aircraft before and after decontamination operations. With these measurements, they evaluated the contributions of various aircraft sections to exposure rates inside the cockpit (76).

Project 7.1a, Electromagnetic Effects from Atomic Explosions, was conducted by the National Bureau of Standards, Air Force Cambridge Research Center, Air Weather Service, and the Geophysical Laboratory of the University of California at Los Angeles. The project was designed to study the electromagnetic pulses produced by a nuclear detonation. Data were evaluated as a means of determining the location of distant nuclear detonations. Onsite stations were at Frenchman and Yucca Flats, and offsite stations in Colorado, Florida, Georgia, Massachusetts, New Mexico, Virginia, Bermuda, Germany, and Puerto Rico. Three hours before the detonation, five project participants proceeded to Station 7.1a, about 12 kilometers from ground zero, and remained there until after the shot (63; 64).

Project 7.1b, Long Range Light Measurements, was conducted entirely offsite by EG&G and Headquarters, Air Force. The objective was to study the long-range detection of light produced

by a nuclear detonation. EG&G and the Air Force established light-detecting stations in Arizona, Idaho, Texas, and Washington. An estimated two EG&G employees and ten Air Force personnel from the Sacramento Air Materiel Area, McClellan AFB, operated each station from about six hours before to one hour after the detonation (35).

Project 7.2, Detection of Airborne Low-frequency Sound from Atomic Explosions, was conducted by Headquarters, Air Force, assisted by the Signal Corps Engineering Laboratories and the National Bureau of Standards. The objective was to determine the accuracy of long-range acoustic detection methods. The Signal Corps Engineering Laboratories operated stations in Washington, Alaska, Hawaii, Kentucky, New Jersey, and Texas. The National Bureau of Standards operated a station in Washington, D.C. (65).

Project 7.3, Radiochemical and Physical Analysis of Atomic Bomb Debris, was conducted by Headquarters, Air Force. The project, which involved analysis of particulate and gaseous samples from the Shot EASY cloud, was conducted in conjunction with Program 13, Radiochemistry Sampling. Cloud sampling, performed by the 4925th Test Group (Atomic) of Kirtland AFB, is discussed in section 2.2.3 of this chapter (71).

Project 7.4, Seismic Waves from A-Bombs Detonated over a Desert Valley, was conducted by the Air Force 1009th Special Weapons Squadron and the Coast and Geodetic Survey. The objective was to determine the seismic properties of the geological structure of the test area. Four unmanned stations were located 300, 1,000, 4,500, and 7,500 meters from ground zero. At 0900 hours on the day after the shot, two personnel began retrieving records from the stations, an activity that took about one hour (20).

Project 9.1, Technical and Training Photography, was conducted by personnel from the following agencies (36; 63):

- Air Force Lookout Mountain Laboratory
- Army Pictorial Service Division
- Naval Medical Research Institute
- Signal Corps Engineering Laboratories
- SAC 5th Reconnaissance Technical Squadron
- SAC 28th Reconnaissance Technical Squadron
- Wright Air Development Center
- 4925th Test Group (Atomic).

To photograph the detonation, project personnel went to three stations about 15 kilometers and one station about 11 kilometers from ground zero about three hours before the shot. Lookout Mountain Laboratory personnel photographed Shot EASY from a C-47 aircraft that left Indian Springs AFB at 0335 hours and returned at 0440 hours (36; 63). Project 9.1 personnel also took still photographs and motion pictures of various Military Effects Test Group projects.

Project 9.2, Air Weather Service Participation, involved Air Force personnel who compiled data from various weather stations at the NPG and offsite, prepared weather maps, and briefed NPG officials on current and predicted weather conditions. Project participants were from the 6th Weather Squadron (Mobile) of the 2059th Air Weather Wing, Tinker AFB, Oklahoma. These personnel were deployed as follows (54):

- Eight forecasters, 13 weather observers, and two equipment operators at the Control Point Weather Station near Yucca Pass
- Twelve airmen in the Rawinsonde Weather Observation Section at the Control Point and 11 airmen from that section at a station in Tonopah, Nevada
- Three airmen in the Pibal Weather Observation Section at Beatty, Caliente, Crystal Springs, Currant, and Warm Springs, Nevada, and St. George, Utah.

At 2000 hours the evening before the detonation, two of the project personnel stationed at the Control Point entered the shot area to check instruments near the tower. They rechecked the instruments hourly until three hours before shot-time, when they returned to the Control Point (54; 63).

Project 9.4, Effects of Atomic Explosions on the Ionosphere, was conducted by the Signal Corps Engineering Laboratories, with assistance from personnel of the 9471st Technical Service Unit. The objective was tc obtain data on the effects of a nuclear detonation on ionospheric radiowave propagation. Project personnel worked at transmitter and receiver stations. The only onsite facility was a transmitter at Station 9.4, 910 meters north of the Control Point. Two other transmitters were at Mather AFB, Sacramento, California. The radio receiver stations were at the Navaho Ordnance Depot, Flagstaff, Arizona; White Sands Proving Ground, New Mexico; and Fort Sill, Oklahoma.

On the day before the shot, personnel practiced operating the transmitters and receivers. On shot-day, they operated instruments from one hour before to one hour after the shot. Information obtained at the project stations was sent for analysis to the Signal Corps Engineering Laboratories (28; 63).

Project 9.5, Electromagnetic Radiation over the Radio Spectrum from Nuclear Detonations, was conducted by the Signal Corps Engineering Laboratories, with assistance from the 9467th Technical Service Unit, Electronic Warfare Center. The objective was to determine the wave shape and the amplitude of radio frequency energy emanating from a nuclear detonation. During the shot, project personnel operated two stations 16 to 24 kilometers from ground zero. In addition, project participants manned one station at White Sands Proving Ground in New Mexico and another at the Evans Signal Laboratory in Belmar, New Jersey (19).

2.2.2 Department of Defense Participation in Weapons Development Test Group Projects

Although most of the Weapons Development Test Group activities were performed by agencies under contract to the Atomic Energy Commission, some of the projects were conducted by DOD agencies. For example, the Naval Research Laboratory performed the experiments for Program 18, Thermal Measurements. In addition, a few DOD personnel were assigned to LASL or to the Weapons Development Test Group to assist in the projects listed in table 2-1.

Project 10.1, Measurement of Alpha, was conducted by the Naval Research Laboratory. Two hours and 30 minutes before the detonation, four participants left the tower area after checking their instruments. After the detonation, five personnel entered the shot area to recover film from a station 910 meters from ground zero. They remained for one hour. At 0800 hours on the day after the detonation, a party of five returned to the station and remained there for two hours (55; 63).

Project 11.1, Measurement of Transit Time, was conducted by the Naval Research Laboratory. Project participants performed the same activities as those described for Project 10.1 (55; 63).

Project 12.1, Technical Photography, was conducted by personnel from EG&G, with assistance from Navy personnel. They provided technical photography support, including dust studies, preshock turbulence studies, light absorption and mirage studies, fireball growth measurement, thermal effects studies, and other coverage required by the Weapons Development Test Group.

Two days before the shot, project personnel prepared the film at the Control Point Building. The afternoon before Shot EASY, personnel loaded film into remote-controlled cameras located at various stations in the ground zero area. After the

detonation, EG&G personnel recovered the exposed film and processed some of it in the mobile unit set up in the Control Point area. The remaining film was flown to laboratories of Consolidated Film Industries in Hollywood, California, or in the city of Fort Lee, New Jersey, for processing (42).

Project 12.1c, Bhangmeter Mod II, was conducted by EG&G. The objective was to evaluate and test a new bhangmeter, which was used to measure the yield of a detonation. Project personnel installed these instruments at the Control Point. Bhangmeter readings recorded at shot-time were analyzed after the shot (41).

Project 12.2a-d, High-speed Photography, was conducted by LASL and EG&G. The objectives were to study early fireball growth and obtain measurements correlating shock arrival time with the appearance of the fireball. Project personnel installed cameras 1,600 meters from the shot-tower. After the detonation, project personnel retrieved the film for analysis (38).

Program 13, Radiochemistry Sampling, involved cloud sampling by personnel from the 4925th Test Group (Atomic). Sampling missions are discussed in section 2.2.3, on AFSWC activities (36).

Project 15.2, Gamma Radiation Exposure as a Function of Distance, was conducted by personnel from LASL. The objective was to measure gamma radiation exposure at various distances from the detonation. Project personnel placed gamma-detecting instruments in the ground at distances of 1,370 to 3,480 meters from ground zero. After the detonation, two men in a weapons carrier entered the shot area to recover the instruments. This activity was scheduled to take about 30 minutes (75).

Projects 17.1 and 17.2, External Neutron Measurements, were conducted by personnel from LASL. The objective of these projects was to use threshold detectors to measure external

neutron flux as a function of distance. LASL also provided some threshold detectors to the Naval Radiological Defense Laboratory and to the Naval Research Laboratory.

Project personnel attached some threshold detectors to horizontal steel bars about four feet above the ground along a radial line 460 to 1,470 meters from the shot-tower. Other detectors were fastened to a steel cable. Participants also installed an underground shelter containing oscilloscopes set to run automatically at shot-time. After the detonation, personnel retrieved the steel cable by using a tractor to drag it out of the test area. Other personnel recovered records from the underground shelters and retrieved the steel bars with the threshold detectors. At Yucca Lake, the detectors were removed from the bars and from the cable. AFSWC courier aircraft then transported the detectors to LASL for analysis (27).

Project 18.1, Total Thermal Radiation and Atmospheric Transmission, was conducted by the Naval Research Laboratory to study the transmission of light and thermal radiation emitted by nuclear detonations of various yields. To measure the transmission of light, project personnel placed one photoelectric brightness meter at the Control Point and another in Area 2 of the NPG. In addition, they installed a transmissometer near the BUSTER-JANGLE Y and a receiver at the Control Point. Participants manually operated the instruments at the Control Point during the shot. To obtain data on thermal radiation emissions, personnel installed four thermopile recorder systems and operated them from the Control Point during the shot. They shut down equipment after the detonation to analyze recorded data (60).

Project 18.3, Color Temperatures, was conducted by the Naval Research Laboratory to measure the spectral characteristics of a nuclear fireball as a function of time. Measurements were taken with a high-speed spectrograph (39).

Project 18.4, High-resolution Spectroscopy, was conducted by the Naval Research Laboratory to supplement information obtained from spectroscopy measurements taken during previous nuclear weapons testing series, such as Operations GREENHOUSE and BUSTER-JANGLE. Personnel installed a spectrograph at the Control Point, 14 kilometers from ground zero (16).

Projects 19.1c and 19.1d, Shock-gauge Evaluations Tests, were conducted by Sandia Laboratory. Personnel from LASL and contractors assisted in calibrating and installing instruments. The project was intended to develop and test new instruments for measuring dynamic and static pressures, wind directions, sound and wind speeds, and temperature rises resulting from a shock wave. Project personnel installed instruments at a station located 670 meters from ground zero. Cables connected the instruments to equipment that recorded the information (26).

Project 19.1e, Air Shock Pressures as Affected by Hills and Dales, was conducted by personnel from Sandia Corporation and AEC contractors. The objective was to collect more information about the influence of hills and valleys on the shock waves from air-bursts and to study the shielding effects of hills. Personnel installed gauges to record air shock pressure at six locations, from 5,010 to 5,510 meters west of ground zero, in a line running over a hill. Cables connected the gauges to recording equipment in a nearby mobile van. Sometime after the detonation, participants recovered the records from the van (61).

Projects 19.2a and 19.2b, Blast-wave Material Velocity Measurements, were conducted by LASL. EG&G provided photography services. The objective was to photograph peak overpressure phenomena associated with a nuclear burst. Smoke canisters were fired into the air from 90-millimeter guns immediately before the burst so that air disturbances would be visible. The guns were fired by an electronic timing device. Before the shot, project

personnel entered the shot area to set up four 90-millimeter gun stations southwest of ground zero and load the guns. Other participants placed film in the automatically operated camera stations. EG&G personnel retrieved the film after the shot (68).

2.2.3 Air Force Special Weapons Center Activities

During Shot EASY, AFSWC personnel conducted cloud-sampling missions and sample courier missions for the test groups, and cloud-tracking missions and aerial radiological surveys of the terrain for the Test Manager. The Air Force Special Weapons Center also provided personnel to staff the Air Operations Center, located at the Control Point. The following listing indicates the types and numbers of aircraft and the estimated numbers of AFSWC aircrew personnel involved in missions at Shot EASY (1-3; 5; 36; 37; 52; 69):

TITLE	TYPE OF AIRCRAFT	NUMBER OF AIRCRAFT	NUMBER OF PERSONNEL
Sampling			
Sampler Control	B-29	1	9
Sampler	B-29	1	8
Sampler	T-33	3	6
Sampler	F-84	4	4
Sample Courier Service	B-25	2	10
	C-47	2	8
Cloud Tracking	B-25	1	5
	B-29	2	20
Aerial Surveys of Terrain	C-47	2	10
	L-20	1	2

Cloud Sampling

One B-29, three T-33s, and four F-84s collected particulate and gaseous samples of the Shot EASY cloud for Project 7.3,

Radiochemical and Physical Analysis of Atomic Bomb Debris, and for Program 13, Radiochemistry Sampling. Two other T-33s aborted their missions shortly after leaving Indian Springs AFB. A B-29 sampler control aircraft, with an AFSWC aircrew and a LASL scientific advisor onboard, directed the operations of the sampler aircraft. The samplers flew at altitudes of 31,000 to 33,000 feet and made a total of 17 penetrations of the cloud. The following listing details their activities (1-3; 36; 37; 52; 69):

AIRCRAFT TYPE AND TAIL NUMBER	TAKEOFF TIME	TOTAL TIME IN CLOUD (seconds)	TOTAL DOSIMETER READING (roentgens)	LANDING TIME
Sampler Control B-29 (386)	0350			1030
B-29 (285)	0400	NR*	0.675	0925
T-33 (920)	0535	NR	0.700	0725
T-33 (048)	0526	NR	NR	0625
T-33 (913)	0535	NR	0.440	0725
F-84 (040)	0558	NR	0.050	0815
F-84 (054)	0605	120	0.030	0735
F-84 (043)	0608	NR	NR	0735
F-84 (042)	0610	NR	0.800	0745

*NR indicates not reported.

On completing their mission, the samplers returned to Indian Springs AFB and parked in the northeast corner of the parking area. Pilots then shut down the engines and opened the aircraft canopies. The B-29 crews left the aircraft through the rear door between the stabilizer and the wing. The T-33 and F-84 crews

disembarked by stepping onto a boarding ladder attached to the side of the aircraft. The sample-removing team and radiological safety monitors used long-handled tools to take samples from the aircraft and place them in shielded containers. They used the same method to remove the bottles containing the gaseous samples. They then loaded the sample containers onto courier aircraft for delivery to laboratories for analysis (1-3; 36; 37; 52; 69).

Courier Missions

After the sampling missions had been completed, two B-25 and two C-47 aircraft left Indian Springs AFB on shot-day to transport samples and filter papers to various laboratories. The 4901st Support Wing (Atomic) conducted these courier missions (1-3; 36; 37; 52; 69).

At about 0715 hours, a B-25 flew from Indian Springs AFB to McClellan AFB with Project 7.3 samples. At 0815 hours, a C-47 flew from Indian Springs AFB to LASL with Program 13 samples. A B-25 also left Yucca Lake airstrip at 0815 hours with Project 17.1 samples for LASL. At 0915 hours, a B-25 flew from Indian Springs AFB to the Army Chemical Center with Project 6.3 samples (1-3; 36; 37; 52; 69).

Cloud Tracking

One B-25 and two B-29s from Indian Springs AFB flew cloud-tracking missions over and beyond the Nevada Proving Ground. The B-25 (tail number 099) left at 0433 hours, tracked the cloud at heights ranging from 4,000 to 14,000 feet above the terrain, and returned at 0950 hours. One B-29 (tail number not given) took off at 0430 hours to track the cloud at heights of 10,000 to 24,000 feet. This aircraft was forced to abort its mission and was replaced by a second B-29 (tail number 826), which left Indian Springs at 0556 hours and returred at 0700 hours (1-3; 36; 37; 52; 69).

Aerial Surveys of Terrain

After the detonation, two C-47s and one L-20, based at Indian Springs AFB, conducted radiological surveys of the onsite and offsite terrain. One C-47 (tail number 386) left at 0530 hours, flew at heights of 700 to 5,000 feet, and returned at 1200 hours. The other C-47 (tail number 308) left at 0715 hours, conducted its survey at an altitude of 10,000 feet, and returned at 1230 hours. The L-20 (tail number 464) left at an undesignated time, conducted its survey at 1,000 to 7,500 feet above the terrain, and landed at an unreported time (1-3; 36; 37; 52; 69).

2.3 RADIATION PROTECTION AT SHOT EASY

The main purpose of the radiation protection procedures developed by the test groups and AFSWC for Operation TUMBLER-SNAPPER was to keep individual exposures to ionizing radiation to a minimum, while still allowing participants to accomplish their missions.

Logistics and Materiel

During the period 7 May to 24 May 1952, which covered the 7 May detonation of Shot EASY, the Logistics and Materiel Department issued about 525 film badges to test group personnel (both DOD and AEC personnel are included in this group). The department also issued 1,174 sets of protective clothing and 253 radiation survey instruments (43).

Monitoring

The initial ground radiation survey began at 0522 hours, slightly more than an hour after the detonation, and continued until 0650 hours. Because of the relatively large radiation area and the rough terrain, it was not possible to complete the survey, as indicated in figure 2-3. The closest that the initial

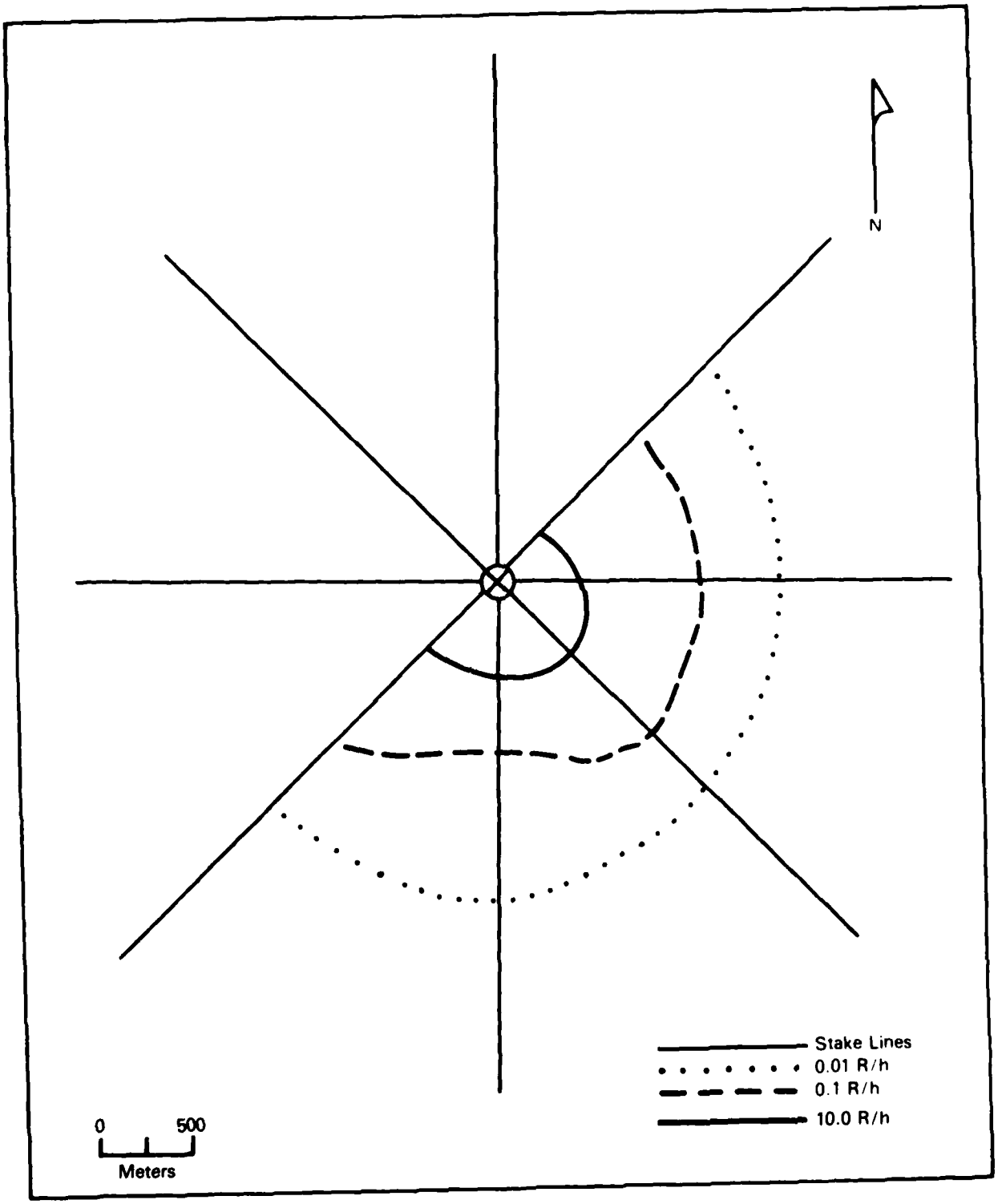


Figure 2-3: INITIAL RADIATION ISOINTENSITY MAP FOR SHOT EASY, 7 MAY 1952, 0530 HOURS

survey monitors approached to ground zero was 365 meters, where the maximum intensity recorded was 10.0 R/h.

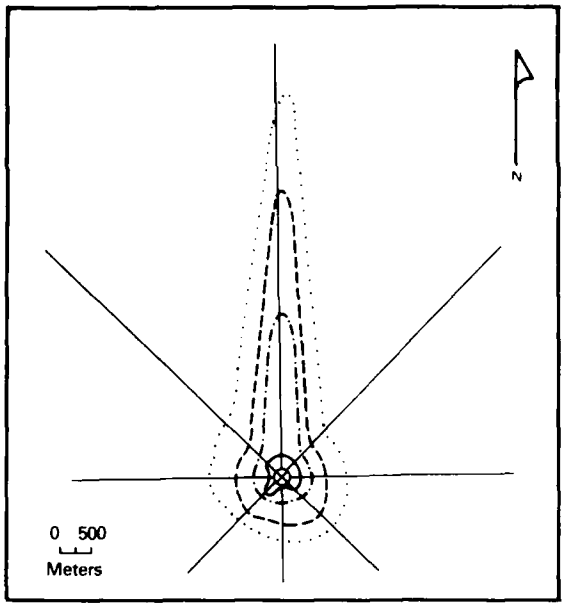
A helicopter conducted an aerial survey of the shot area 30 minutes after the detonation. The intensity recorded near ground zero was 50 R/h. The height at which this reading was taken is not known (43).

Mobile ground teams participated in offsite monitoring. During the night preceding the detonation, they traveled to monitoring stations in the expected path of the fallout. Most of the fallout was to the north and northeast of the Nevada Proving Ground. The teams recorded a maximum intensity of 1.2 R/h two hours after the detonation at a location approximately 75 kilometers north of ground zero (43).

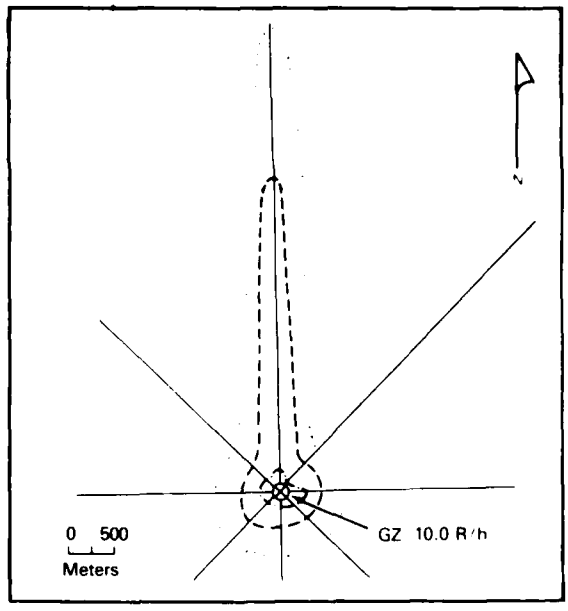
Two C-47 and one L-20 aircraft also conducted offsite aerial surveys of the terrain. The maximum intensity encountered was 0.02 R/h, 150 feet above a location southeast of Lincoln Mine, Nevada, approximately 70 kilometers northeast of ground zero, almost four hours after the detonation (36; 43).

Plotting and Briefing

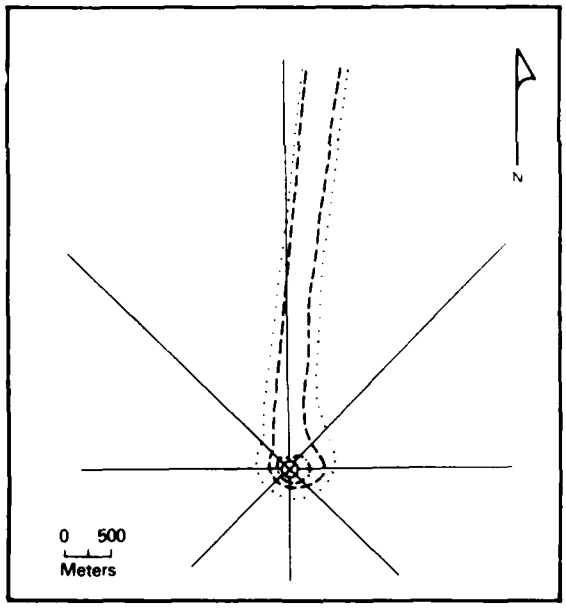
Monitoring teams provided survey data used in plotting radiation isointensity contours. The radiation intensity map resulting from the initial, incomplete survey is shown in figure 2-3. The early surveys did not locate the extent of the contamination northeast of ground zero. The isointensity maps generated from resurveys are shown in figure 2-4 (43). The labels of the maps in the source document do not always reflect the range of survey times given in the tables of intensity readings that accompany the maps.



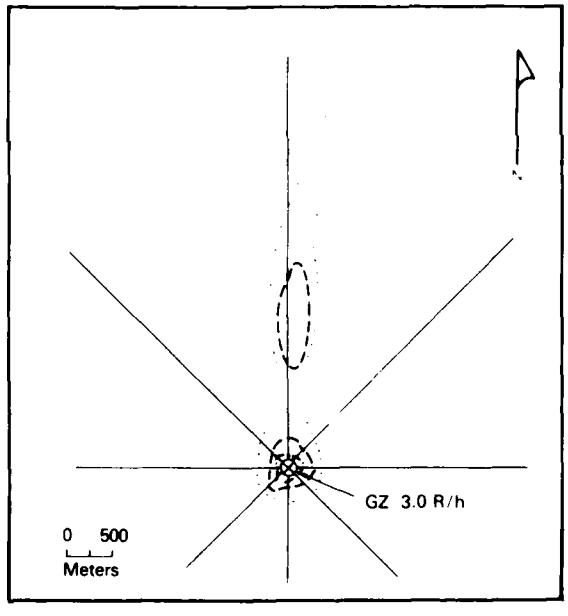
9 MAY 1952, 0530 HOURS



12 MAY 1952, 0530 HOURS



15 MAY 1952, 0530 HOURS



23 MAY 1952, 0530 HOURS

Stake Lines
0.01 R/h
0.1 R/h
1.0 R/h
10.0 R/h

Figure 2-4: SUBSEQUENT RADIATION ISOINTENSITY MAPS FOR SHOT EASY

Decontamination

Because Shot EASY produced high levels of radioactivity, contamination of recovery equipment and vehicles was a significant problem. A complete crew worked through the night at the Vehicle Decontamination Center (43).

Dosimetry Data

No individual at Shot EASY exceeded the 3.0 roentgen exposure limit. However, exposures for individuals working in radiation areas showed a sharp rise, as compared to earlier shots. No cumulative exposure from the four previous shots exceeded 0.55 roentgens, but 82 individuals who turned in film badges during the period 7 May through 24 May accumulated exposures between 0.5 and 2.0 roentgens (43).

SHOT FOX SYNOPSIS

AEC TEST SERIES:	TUMBLER-SNAPPER
DOD EXERCISE:	Exercise Desert Rock IV
DATE/TIME:	25 May 1952, 0400 hours
YIELD:	11 kilotons
HEIGHT OF BURST:	300 feet (tower)

DOD Objective: To determine the military value of weapons effects for offensive and defensive deployment.

Weather: At shot-time, the surface winds were calm. Winds were ten knots at 10,000 feet, eight knots at 20,000 feet, and 25 knots at 30,000 feet, all from the southwest. The temperature was 14°C, the relative humidity was 41 percent, and the pressure was 868 millibars.

Radiation Data: Most onsite fallout occurred northeast of ground zero, overlapping residual radiation from Shot EASY. Ninety minutes after the shot, the 0.01 R/h line extended farther than 6.5 kilometers to the east. High radiation levels to the northeast prevented completion of the initial survey on shot-day.

Participants: Exercise Desert Rock IV troops; Los Alamos Scientific Laboratory; Armed Forces Special Weapons Project; Atomic Energy Commission; Air Force Special Weapons Center; contractors.

CHAPTER 3

SHOT FOX

Shot FOX was detonated with a yield of 11 kilotons at 0400 hours Pacific Standard Time on 25 May 1952. FOX, the sixth nuclear test of Operation TUMBLER-SNAPPER, was originally scheduled for 13 May 1952 but was rescheduled for 25 May because of a misfiring of the device and adverse weather conditions. Shot FOX, a weapons development test, was part of the SNAPPER phase of Operation TUMBLER-SNAPPER. Developed by the Los Alamos Scientific Laboratory, the FOX device was detonated on a 300-foot tower in Area 4 of Yucca Flat, UTM coordinates 795056. The Shot FOX cloud reached a height of about 41,000 feet and drifted east into Utah (1; 2; 8; 30; 31; 40; 67).

3.1 EXERCISE DESERT ROCK IV OPERATIONS AT SHOT FOX

Approximately 1,450 military observers participated in Desert Rock IV programs at Shot FOX. Camp Desert Rock support troops provided radiological safety, transportation, communications, and control functions for the observers in the forward area. No tactical troop maneuver was conducted at the shot (11; 12; 15; 50; 51; 58).

3.1.1 Participation of Camp Desert Rock Support Troops

In providing support for the observer program, the Camp Desert Rock troops sometimes entered the forward area. Two special staff sections, the Desert Rock Radiological Safety Group and the Instructor Group, were particularly involved in shot-day operations.

The Desert Rock Radiological Safety Group implemented radiological safety procedures and was assisted by the AFSWP Radiological Safety Group in radiation surveys. Each survey team consisted of one driver, one radio operator, and one radiological safety monitor from the Radiological Safety Group. An AFSWP radiological safety team accompanied Companies A, B, C, and D of the 701st Armored Infantry Battalion into the forward area. The 701st provided additional radiological monitoring for its units that went into the shot area (49; 51; 53).

The Instructor Group consisted of AFSWP personnel who replaced the less experienced Army personnel used at Shots CHARLIE and DOG. After the detonation, the instructors led observers through the display area to view the damage. They noted differences between the predicted and actual effects of the burst (51).

In addition to the Instructor Group and the Desert Rock Radiological Safety Group, several other Desert Rock support elements participated in activities at Shot FOX.

Before the shot, personnel from the 369th Engineer Amphibious Support Regiment spent several days in the equipment display area placing military vehicles and ordnance at various distances from ground zero. Observers compared the preshot and postshot condition of these displays (49; 51).

The 31st and 23rd Transportation Truck Companies transported military personnel to and from the forward area. At shot-time, the vehicles were parked about 1,000 meters south of the observer trenches (49; 51).

The Desert Rock Signal Detachment established wire and radio communications within the forward area, as well as at Camp Desert Rock. After the shot, signal personnel operated the two mobile

public address systems in the display area to assist the Instructor Group in its presentations (49; 51).

The medical detachment provided medical support in the forward area and at Camp Desert Rock. One doctor and six enlisted men set up an aid station in the parking area south of the trenches and remained there throughout the exercise (49; 51).

During the shot-day activities, nine officers and 39 enlisted men from Company A, 505th Military Police Battalion, maintained traffic control for Desert Rock convoys in the forward area of the test site and at the FOX trench area (49; 51).

3.1.2 Troop Observer Activities

The observers at FOX consisted of 950 soldiers from the 701st Armored Infantry Battalion, 1st Armored Division, from Fort Hood, Texas, and an additional 500 participants from the continental armies and service schools (15).

Two Army contractors, the Human Resources Research Office (HumRRO) of George Washington University and the Operations Research Office (ORO) of Johns Hopkins University, conducted psychological tests on 670 of the observers from the 701st Armored Infantry Battalion. The general objective of these studies was to evaluate the participants' psychological reactions to various aspects of their Desert Rock IV experience. These psychological tests were a continuation of similar studies conducted by HumRRO and ORO at Exercise Desert Rock I during Operation BUSTER-JANGLE in '951 (53).

At TUMBLER-SNAPPER, HumRRO and ORO research was conducted mainly at Shots CHARLIE, FOX, and GEORGE. In particular, the experiments were designed to gather data on (17; 51; 53; 78):

- The effectiveness of a special preshot indoctrination in increasing troops' retention of information as compared to the effectiveness of a more limited presentation on nuclear effects

- The reactions of the troops to the exercise as related to the indoctrination they had received

- The nature and extent of fears relating to the nuclear detonation and its effects

- The participants' self-confidence and adjustment to the situation as reflected in their attitude and their willingness to volunteer for future potentially hazardous missions or maneuvers

- The extent to which participating troops talked about the exercise and the nuclear detonation with nonparticipants after their return to their home stations.

HumRRO and ORO personnel used questionnaires, tests that involved the interpretation of pictured activities, sweat tests in which hand-sweating was an index of fear, and rifle disassembly-assembly tests that examined to what extent witnessing a burst affected manual dexterity.

Originally, Camp Desert Rock support units were to participate in these experiments. However, because of delays in the detonation and the arrival of the 701st Armored Infantry Battalion for Shot GEORGE, the 701st was allowed to witness Shot FOX and return to its home station before Shot GEORGE. Three Army battalions were part of the HumRRO and ORO experiments and were divided into the following groups (48; 53):

- "Indoctrinated troops" (483 men)
  - Companies A, B, and C, 701st Armored Infantry Battalion

- "Briefed troops" (189 men)
  - Company D, 701st Armored Infantry Battalion

- "Nonparticipants" (914 men)
  - 634th Armored Infantry Battalion
  - 702nd Armored Infantry Battalion.

In the months preceding the Desert Rock IV maneuver, the "indoctrinated troops" were instructed on chemical, biological, and radiological topics at their home stations. At Camp Desert Rock, these troops were given an additional four hours of special indoctrination in nuclear effects. The "briefed troops" received the four-hour onsite indoctrination but were not instructed at their bases. At Shot FOX, both the "indoctrinated troops" and "briefed troops" took part in the psychological tests at the Nevada Proving Ground. The "nonparticipants" remained at Fort Hood throughout the Desert Rock IV exercises and were given psychological tests before, during, and after the Desert Rock maneuver.

Troops from Companies A, B, C, and D of the 701st left Fort Hood by train on 20 May 1952. They arrived at Camp Desert Rock on 22 May 1952. On 23 May, Companies A, B, and C attended four one-hour indoctrination lectures on bomb effects and on the previous TUMBLER-SNAPPER detonations (53).

On 24 May 1952, at 1120 hours, Companies A, B, C, and D boarded trucks at Camp Desert Rock and traveled to the FOX shot area to practice their shot-day activities. While in the trench area, shown in figure 3-1, these troops were briefed on what to expect at the detonation and the specific precautions to take during the nuclear test. This onsite briefing also included an inspection of the equipment display area and a drill using an artillery shell fired to simulate the FOX detonation. Following these activities, the troops returned to Camp Desert Rock and underwent psychological testing from 2000 to 2200 hours (49; 51).

At about 0050 hours on 25 May, the entire 701st Armored Infantry Battalion again moved by truck convoy from Camp Desert Rock to the shot area. The convoy proceeded north along Mercury Highway to the FOX trench area, arriving at about 0220 hours. The trenches, located in Area 1, were about 6,400 meters from

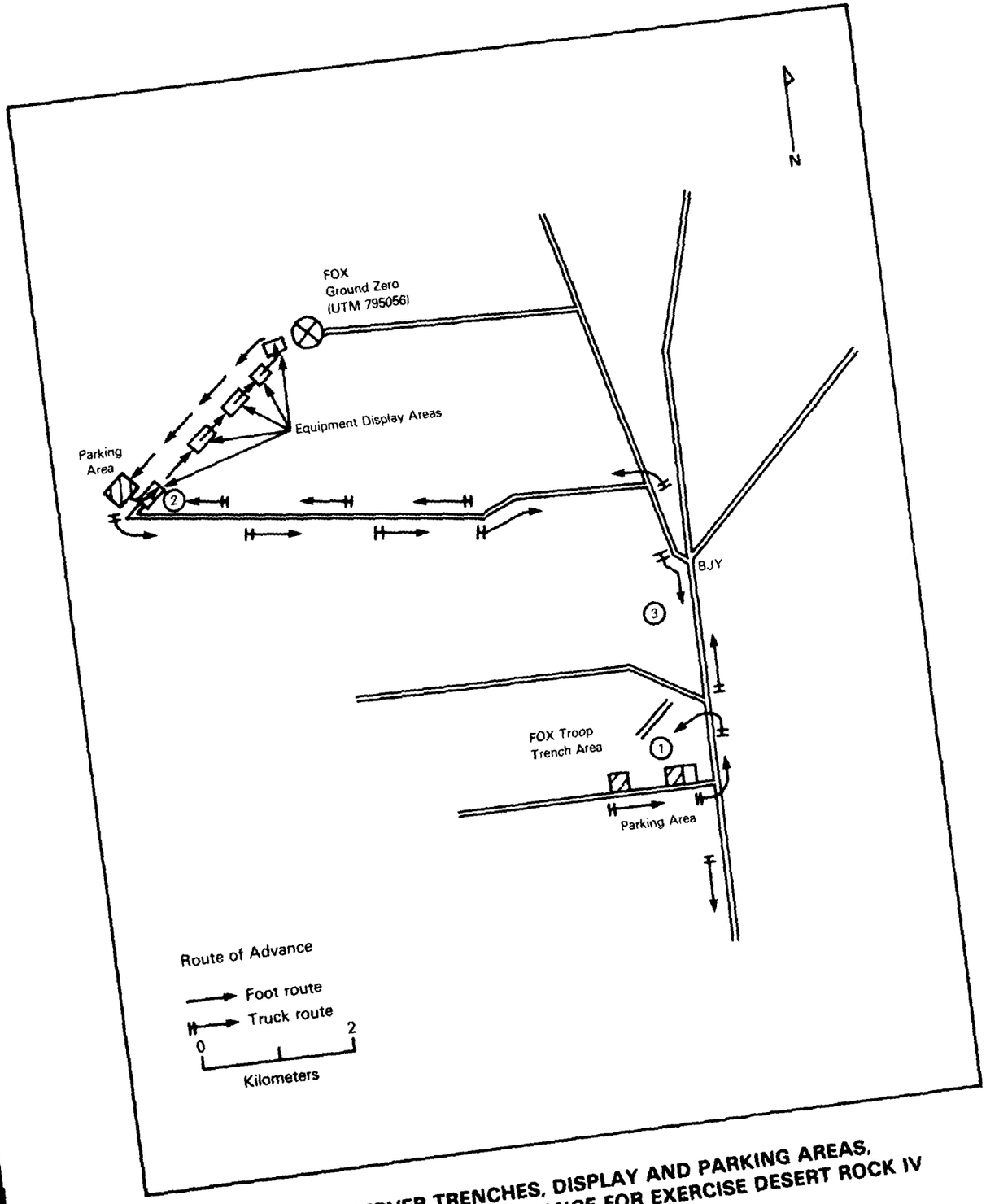


Figure 3-1: OBSERVER TRENCHES, DISPLAY AND PARKING AREAS, AND ROUTES OF ADVANCE FOR EXERCISE DESERT ROCK IV ACTIVITIES AT SHOT FOX

ground zero. The troops went to their trenches, and the Instructor Group used the public address system to conduct a 30-minute preshot briefing, similar to that given during the practice on the previous day. The troops participating in this maneuver wore fatigue uniforms, web belts with canteens, and combat boots and film badges. They carried rifles and protective masks (48; 49).

At 0345 hours, 15 minutes before the detonation, the HumRRO and ORO monitors began administering the sweat tests to 248 men. At 0350 hours, the troops were ordered to enter the trenches. Then at 0356, HumRRO and ORO monitors administered another sweat test to selected individuals. At 0358 hours, all personnel were given the two-minute warning for the shot. Troops were ordered to crouch below ground level and await the order to stand up following the detonation (17; 48; 49; 53; 78).

At 0400 hours, the FOX device was detonated as planned, and five seconds later a Desert Rock instructor gave the command over the public address system for the troops to rise in the trenches. Twenty seconds after the detonation, the blast wave passed over the observer trenches. Soon after, all troops participating in the sweat test were directed to hand in instruments to the monitors (17; 48; 49; 53; 78).

Selected troops performed the rifle disassembly-assembly task at the trench area, probably in the first few minutes after the detonation. At 0415 hours, the HumRRO and ORO monitors gave the troops in the trench area a brief psychological test, consisting of a questionnaire about their reactions to the detonation. Meanwhile, AFSWP and Desert Rock radiological safety monitors went forward to survey the shot area.

At about 0630 hours, when the area was declared radiologically safe for operations, troops boarded the trucks, which had

been brought to the trench area. The troops were then taken to the shot area to view the damage to the equipment displays, located southwest of ground zero, as shown in figure 3-1. The trucks were parked in a predesignated area southwest of the equipment display, and the troops walked to the displays with radiological safety monitors from Camp Desert Rock in the lead. Army Chemical, Biological, and Radiological (CBR) monitors, without AFSWP supervision, surveyed the approach route to the equipment display. At the equipment displays, Instructor Group personnel used the public address systems and loudspeakers posted throughout the area to comment on the damage caused by the detonation (17; 48; 49; 53; 78).

After viewing the equipment displays, the troops returned to the truck parking area for the trip to Camp Desert Rock. The troops probably left the parking area at 0930 hours for Camp Desert Rock, which they reached by 1130 hours. Beginning at 1400 hours, HumRRO and ORO monitors gave the troops a postshot psychological test, consisting of a questionnaire.

The next day at 0500 hours, troops were given a second sweat test to compare the data obtained during the nuclear detonation with data obtained from the same troops in a less stressful situation. At 0900 hours, monitors gave a "volunteer" test, in which the troops were asked if they would like to participate in another nuclear weapons maneuver.

On 28 May 1952, the 701st Armored Infantry Battalion began its return to Fort Hood, arriving there on 30 May. At Fort Hood, the monitor teams continued to conduct psychological testing from 3 to 16 June 1952, when the HumRRO and ORO experiment was completed (17; 47-49; 51; 53; 78).

3.2 DEPARTMENT OF DEFENSE PARTICIPATION IN SCIENTIFIC AND SUPPORT ACTIVITIES AT SHOT FOX

Department of Defense personnel took part in scientific and diagnostic projects conducted by the Military Effects Test Group and the Weapons Development Test Group. Table 3-1 lists the test group projects and identifies the participating organizations. In addition to the DOD personnel participating in test group experiments, Air Force Special Weapons Center personnel provided air support to the test groups and to the Test Manager.

3.2.1 Military Effects Test Group Projects

As table 3-1 shows, the Military Effects Test Group fielded 18 projects involving DOD personnel at Shot FOX (8). The following descriptions of these projects often discuss recovery operations as occurring after the announcement of recovery hour. Recovery hour was declared at about 0630 hours.

Project 1.4, Air Blast Measurements, was conducted by the Ballistic Research Laboratories. The objective was to use radiotelemetering systems to determine blast arrival time. Before the detonation, project personnel installed two lines of blast switches 370 to 610 meters and 760 to 1,070 meters from ground zero. Transmitter stations were placed 640 and 950 meters from ground zero. In addition, participants established a receiver station about 16 kilometers from the transmitters. A recovery party entered the shot area two days after the detonation to inspect and retrieve the instruments (14; 63).

Project 2.1, Total Gamma Exposure versus Distance, was conducted by the Signal Corps Engineering Laboratories. The objective was to measure gamma radiation exposure as a function of distance. Project personnel placed National Bureau of Standards film packets at 90-meter intervals along a radial line extending 1,100 to 2,740 meters east of ground zero. About two

Table 3-1: TEST GROUP ACTIVITIES WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT FOX

Project/ Program	Title	Participants
Military Effects Test Group		
1.4	Air Blast Measurements	Ballistic Research Laboratories
2.1	Total Gamma Exposure versus Distance	Signal Corps Engineering Laboratories
2.2	Gamma Ray Energy Spectrum of Residual Contamination	Signal Corps Engineering Laboratories
6.1	Evaluation of Military Radiac Equipment	Bureau of Ships; Signal Corps Engineering Laboratories
6.3	Evaluation of a Filtration System for Pressurized Aircraft	Army Chemical Center
6.4	Operational Tests of Radar and Photographic Techniques for IBDA	Wright Air Development Center; Strategic Air Command
6.5	Decontamination of Aircraft	Wright Air Development Center; Naval Radiological Defense Laboratory
6.7	Evaluation of Air Monitoring Instruments	Army Chemical Center
7.1a	Electromagnetic Effects from Atomic Explosions	National Bureau of Standards; Air Force Cambridge Research Center; Air Weather Service; Geophysical Laboratory of the University of California at Los Angeles
7.1b	Long Range Light Measurements	EG&G; Headquarters, Air Force
7.2	Detection of Airborne Low-frequency Sound from Atomic Explosions	Headquarters, Air Force; Signal Corps Engineering Laboratories; National Bureau of Standards
7.3	Radiochemical and Physical Analysis of Atomic Bomb Debris	Headquarters, Air Force
7.4	Seismic Waves from A-Bombs Detonated over a Desert Valley	Air Force 1009th Special Weapons Squadron; Coast and Geodetic Survey
8.7	Thermal Radiation Measurements	Department of Engineering, University of California at Los Angeles
9.1	Technical and Training Photography	Naval Medical Research Institute; Air Force Lookout Mountain Laboratory; Wright Air Development Center; Army Pictorial Service Division; 4925th Test Group (Atomic); SAC 5th and 28th Reconnaissance Technical Squadrons; Signal Corps Engineering Laboratories
9.2	Air Weather Service Participation	Air Weather Service
9.4	Effects of Atomic Explosions on the Ionosphere	Signal Corps Engineering Laboratories; 9471st Technical Service Unit
9.5	*Electromagnetic Radiation over the Radio Spectrum* from Nuclear Detonations	*Signal Corps Engineering Laboratories;* 9467th Technical Service Unit

Table 3-1: TEST GROUP ACTIVITIES WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT FOX (Continued)

Project/ Program	Title	Participants
	Weapons Development Test Group	
10.1	Measurement of Alpha	Naval Research Laboratory
10.2	Test of Scintillator Optical Path Technique	Naval Research Laboratory
11.1	Measurement of Transit Time	Naval Research Laboratory
12.1	Technical Photography	EG&G
12.1c	Bhangmeter Mod II	EG&G
12.2a-d	High-speed Photography	EG&G; Los Alamos Scientific Laboratory
13	Radiochemistry Sampling Program	4925th Test Group (Atomic)
14	Test of an External Initiator	Los Alamos Scientific Laboratory
15.2	Gamma Radiation Exposure as a Function of Distance	Los Alamos Scientific Laboratory
15.3	Radiation Monitoring Measurements	Los Alamos Scientific Laboratory
17.1 and 17.2	External Neutron Measurements	Los Alamos Scientific Laboratory
18.1	Total Thermal Radiation and Atmospheric Transmission	Naval Research Laboratory
18.4	High-resolution Spectroscopy	Naval Research Laboratory
19.1c-d	Shock-gauge Evaluations Tests	Sandia Laboratory

hours after the declaration of recovery hour, four men drove by truck into the area to retrieve film packets. They recovered the film farthest from ground zero and then worked their way toward ground zero. This task was scheduled to take three hours. Information gained from the film was eventually shared with Projects 1.13, 3.1, and 6.1; the Office, Chief of Army Field Forces; and the Marine Corps (57; 63).

Project 2.2, Gamma Ray Energy Spectrum of Residual Contamination, was conducted by the Signal Corps Engineering Laboratories. The objective was to determine the relative dose contribution of various gamma radiation energies in radiation areas following a nuclear detonation. Project personnel used radiation survey meters that had been modified to shield portions of the gamma ray energy spectrum. The information gained was to be used to determine the radiation exposure potential in test areas and to design survey instruments (77).

Before the shot, project personnel calibrated five AN/PDR-T1B radiac instruments. After the Test Manager announced recovery hour, participants placed the instruments in the shot area 3.5 feet above the ground on wooden tripods facing ground zero. About three hours after the burst, personnel took the first set of radiac instrument readings. At 1,450 meters from ground zero, the intensity was 1.2 R/h. At 3,000 meters from ground zero, the intensity was 0.02 R/h. The day after the shot, personnel returned to the shot area to take more gamma spectral readings. The first reading was taken at about 650 meters from ground zero, where the intensity was 1.09 R/h. Personnel made four other measurements that day at distances up to 1,290 meters from ground zero. Two days after the detonation, Project 2.2 personnel again entered the test area to take another set of gamma energy spectral measurements. The highest intensity, 0.22 R/h, was measured 650 meters from ground zero (63; 77).

Project 6.1, Evaluation of Military Radiac Equipment, was conducted by the Bureau of Ships and the Signal Corps Engineering Laboratories. The objective was to evaluate radiac survey and dose-alarm equipment, dosimeters, and the instruments and techniques used for rapid aerial surveys. Two hours after recovery hour, six project personnel in one vehicle spent three hours recovering dosimeters from radial lines 910 to 2,740 meters east of ground zero. At 0900 hours on the day after the detonation, eight personnel in two vehicles took new readings where the radiation intensity was 8.0 R/h. In addition, Project 6.1 personnel furnished standard and experimental radiation survey instruments to other projects so that the instruments could be evaluated (63; 72).

Project 6.3, Evaluation of a Filtration System for Pressurized Aircraft, was conducted by the Army Chemical Center. The objective was to determine the adequacy of a system for filtering particulate airborne fission products from the cabin air supply of a B-29 aircraft. Air samples taken before and after passing through the filtering unit were compared for levels of radioactivity. The results showed that the filter unit removed more than 99.9 percent of the airborne fission products from the air stream entering the unit (66).

The 4925th Test Group (Atomic) provided the two B-29 aircraft that participated in this project. After five cloud penetrations at altitudes ranging from 30,000 to 33,000 feet, the aircraft returned to Indian Springs AFB. The filter samples were then removed from the B-29s and transported by B-25 courier aircraft to the Army Chemical Center (36; 63; 66). Courier flights are discussed in section 3.2.3 of this chapter, on AFSWC support missions at Shot FOX.

Project 6.4, Operational Tests of Radar and Photographic Techniques for IBDA, was conducted by the Wright Air Development

Center, assisted by the Strategic Air Command. The 509th Bombardment Group of SAC provided three B-50D aircraft from Kirtland AFB to test the Indirect Bomb Damage Assessment (IBDA) system. At altitudes of 22,000, 23,000, and 24,000 feet, the aircraft flew simulated bomb runs with the following departure and landing times:

AIRCRAFT NO.	DEPARTURE TIME	LANDING TIME
1	2300	0927
2	0015	0615
3	0025	0627

Two aircraft reached their simulated release point on time, and the third was five seconds late. After the simulated release, aircraft 1 made a 40-degree banking turn to the right, and aircraft 2 made a 40-degree banking turn to the left. The third aircraft was above and behind the actual drop aircraft. Figure 3-2 shows representative orbit patterns for these aircraft and their positions at shot-time (18; 36).

After the simulated bomb runs, aircraft 1 was to make one pass at 38,200 feet, and then to make three cloud penetrations, at 38,000, 33,400, and 34,600 feet. A radiation detection officer sat in the bombardier's position. The pass at 38,200 feet took 90 seconds, and the maximum radiation intensity noted was 5.0 R/h. The first penetration lasted 220 seconds and registered a peak intensity of 40 R/h, with background readings in the aircraft after penetration of 0.5 R/h. The second penetration lasted 229 seconds and registered a maximum intensity of 20 R/h. The third penetration lasted 150 seconds, with a maximum intensity of 30 R/h. Background radiation levels in the aircraft after the third penetration were 1.8 R/h. This test indicated that radiation intensities encountered in the cloud had no apparent effect on the operation of the AN/APQ-24 radar set (18).

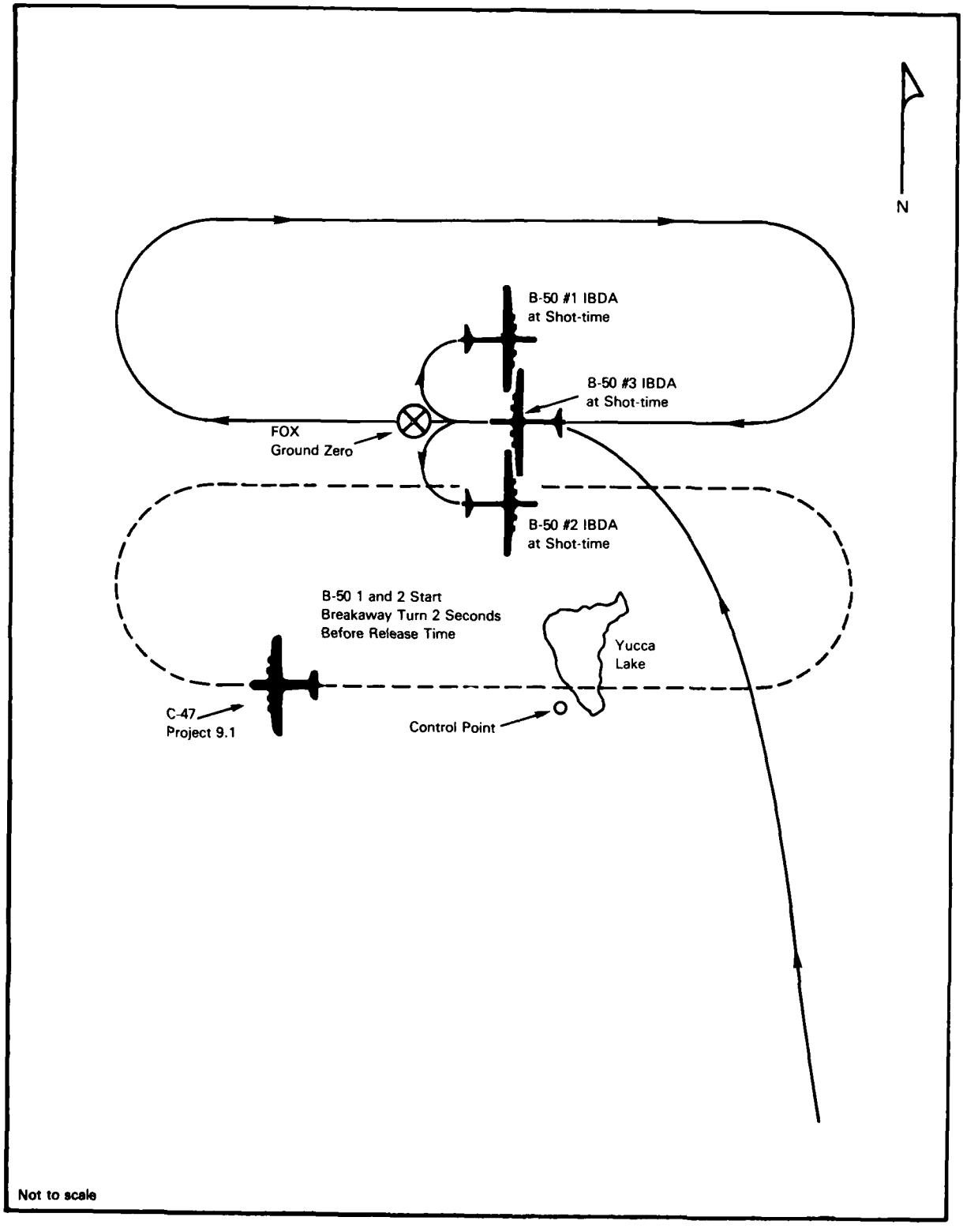


Figure 3-2: REPRESENTATIVE ORBIT PATTERNS FOR PROJECTS 6.4 AND 9.1 AIRCRAFT AT SHOT FOX

Project 6.5, Decontamination of Aircraft, was conducted by the Wright Air Development Center and the Naval Radiological Defense Laboratory. The objective was to study methods of reducing the radiation exposures of maintenance and flight crews.

To study adhesion of contamination to differently treated surfaces, personnel treated various parts of T-33 sampler aircraft with acid, polish, oil, or some combination of the three. After the aircraft returned from the cloud-sampling missions described in section 3.2.3, personnel surveyed radiation intensities in aircraft before and after decontamination.

In another part of this project, personnel attempted to decontaminate the engines of the sampler aircraft. They sprayed water into the air intakes while the engines were running. Measurements were taken at the turbine and in the cockpit, before and after decontamination.

For the third part of the project, participants decontaminated various aircraft sections, one at a time, to study their relative influence on cockpit exposure. Measurements were taken in the cockpit, which remained closed during decontamination, and on exterior surfaces of the aircraft to determine whether reducing the radiation levels on the exterior of the aircraft had any effect on the levels of radiation in the cockpit (63; 76).

Project 6.7, Evaluation of Air Monitoring Instruments, was conducted by the Army Chemical Center to determine the adequacy of a Chemical Corps air sampler for radiological air monitoring. Before the shot, project personnel placed six air samplers at each of four stations located 9.0, 9.2, 10.1, and 10.3 kilometers northeast of ground zero. When instruments were recovered eight hours after the detonation, radiation intensities were 0.018, 0.09, 1.0, and 0.6 R/h, respectively (45).

Project 7.1a, Electromagnetic Effects from Atomic Explosions, was conducted by the National Bureau of Standards, the Air Force Cambridge Research Center, the Air Weather Service, and the Geophysical Laboratory of the University of California at Los Angeles. The project was designed to study the electromagnetic pulses produced by a nuclear detonation at onsite and offsite stations. The onsite stations were at Frenchman and Yucca Flats. Two project participants were at Station 7.1a at Yucca Lake from three hours before the detonation until one hour after recovery hour. The offsite stations were in Colorado, Florida, Georgia, Massachusetts, New Mexico, Virginia, Bermuda, Germany, and Puerto Rico. Data were evaluated to determine the location of distant nuclear detonations (64).

Project 7.1b, Long Range Light Measurements, was conducted offsite by EG&G and Headquarters, Air Force. The objective was to study the long-range detection of light produced by a nuclear detonation. EG&G and the Air Force established light-detecting stations in Arizona, Idaho, Texas, and Washington. An estimated two EG&G employees and ten Air Force personnel from the Sacramento Air Materiel Area, McClellan AFB, operated each station from about six hours before to one hour after the detonation (35).

Project 7.2, Detection of Airborne Low-frequency Sound from Atomic Explosions, was conducted by Headquarters, Air Force, assisted by the Signal Corps Engineering Laboratories and the National Bureau of Standards. The objective was to determine the accuracy of long-range acoustic detection methods. The Signal Corps Engineering Laboratories operated stations in Alaska, Hawaii, Kentucky, New Jersey, Texas, and Washington. The National Bureau of Standards operated a station in Washington, D.C. (65).

Project 7.3, Radiochemical and Physical Analysis of Atomic Bomb Debris, was conducted by Headquarters, Air Force. The project, which involved analysis of particulate and gaseous samples from the Shot FOX cloud, was conducted in conjunction with Program 13, Radiochemistry Sampling. Cloud sampling, performed by the 4925th Test Group (Atomic) of Kirtland AFB, is discussed in section 3.2.3 of this chapter (36; 71).

Project 7.4, Seismic Waves from A-Bombs Detonated over a Desert Valley, was conducted by the Air Force 1009th Special Weapons Squadron and the Coast and Geodetic Survey. The objective was to determine the seismic properties of the geological structure of the test area. Three hours before the detonation, four project members in a jeep and panel truck went to a station at Frenchman Flat, where they stayed until several hours after the detonation. At 0900 hours on the day after the detonation, two personnel in a weapons carrier went to the shot area to recover records. Two days after the detonation, records were recovered from a station one kilometer from Area 4. Records were retrieved from a station 300 meters from ground zero four days after the detonation (20; 63).

Project 8.7, Thermal Radiation Measurements, was performed by the Department of Engineering at UCLA, under contract to the Air Research and Development Command. The project was designed to train personnel of the Department of Engineering in the use of instruments for measuring thermal radiation. These instruments were being developed for Operation IVY. Another objective was to collect data on the thermal radiation emitted from nuclear tests. Data on thermal radiation were recorded at Building 400, located near the Control Point and 18.5 kilometers from the FOX ground zero (70).

Project 9.1, Technical and Training Photography, was conducted by personnel from the following agencies (36; 63):

- Air Force Lookout Mountain Laboratory
- Army Pictorial Service Division
- Naval Medical Research Institute
- Signal Corps Engineering Laboratories
- SAC 5th Reconnaissance Technical Squadron
- SAC 28th Reconnaissance Technical Squadron
- Wright Air Development Center
- 4925th Test Group (Atomic).

In addition to photographing Shot FOX from the ground, Lookout Mountain Laboratory personnel conducted an aerial photography mission in a C-47. The C-47 left Indian Springs AFB at about 0320 hours to be in orbit at shot-time near the shot area. The aircraft was about 13 kilometers south of the FOX tower at shot-time at an altitude of 10,000 feet. The aircraft remained in the area photographing the burst and resulting cloud formation until 0404 hours. It then returned to Indian Springs AFB, arriving at about 0415 hours (36). Project 9.1 personnel also took still photographs and motion pictures of various Military Effects Test Group projects.

Project 9.2, Air Weather Service Participation, involved Air Force personnel who compiled data from various weather stations at the NPG and offsite, prepared weather maps, and briefed NPG officials on current and predicted weather conditions. Project participants were from the 6th Weather Squadron (Mobile) of the 2059th Air Weather Wing, Tinker AFB, Oklahoma. These personnel were deployed as follows (54):

- Eight forecasters, 13 weather observers, and two equipment operators at the Control Point Weather Station near Yucca Pass
- Twelve airmen from the Rawinsonde Weather Observation Section at the Control Point and 11 airmen at a station in Tonopah, Nevada

- Three airmen in the Pibal Weather Observation Section at Beatty, Caliente, Crystal Springs, Currant, and Warm Springs, Nevada, and St. George, Utah.

The evening before the shot, two project personnel entered the shot area at 2000 hours to take readings and check instruments near the shot-tower. The two participants left the tower area and returned to the Control Point about three hours before shot-time. Several hours after the detonation, two participants began retrieving records from the stations, a procedure that took two hours. The next day, personnel reentered the shot area to complete recovery operations (54; 63).

Project 9.4, Effects of Atomic Explosions on the Ionosphere, was conducted by the Signal Corps Engineering Laboratories, with assistance from personnel of the 9471st Technical Service Unit. The objective was to obtain data on the effects of a nuclear detonation on ionospheric radiowave propagation. Project personnel worked at transmitter and receiver stations. The only onsite facility was the transmitter at Station 9.4, 910 meters north of the Control Point. Two other transmitters were at Mather AFB, Sacramento, California. The radio receiver stations were at the Navaho Ordnance Depot in Flagstaff, Arizona; White Sands Proving Ground, New Mexico; and Fort Sill, Oklahoma (28).

On the day before the shot, personnel practiced operating the transmitters and receivers. On shot-day, they operated instruments from one hour before to one hour after the detonation. Information obtained at the project stations was sent for analysis to the Signal Corps Engineering Laboratories (28; 63).

Project 9.5, Electromagnetic Radiation over the Radio Spectrum from Nuclear Detonations, was conducted by the Signal Corps Engineering Laboratories, with assistance from the 9467th Technical Service Unit, Electronic Warfare Center. The project

was designed to determine the wave shape and amplitude of radio frequency energy emanating from a nuclear detonation. Project personnel operated two stations 15 to 25 kilometers from ground zero through the detonation. In addition, project participants manned one station at White Sands Proving Ground in New Mexico and another at the Evans Signal Laboratory in Belmar, New Jersey (19).

3.2.2 Department of Defense Participation in Weapons Development Test Group Projects

Although most of the Weapons Development Test Group projects were conducted by agencies under contract to the AEC, a few DOD personnel were assigned to LASL or to the Weapons Development Test Group. They assisted in the projects listed in table 3-1.

Project 10.1, Measurement of Alpha, and Project 11.1, Measurement of Transit Time, were conducted by the Naval Research Laboratory. After the detonation, four project participants and a radiological safety monitor entered the target area by jeep to recover film from stations about 910 and 1,310 meters east of ground zero. Their estimated working time was one hour (55; 63).

Project 10.2, Test of Scintillator Optical Path Technique, was performed by the Naval Research Laboratory to evaluate experimental equipment for use at Operation IVY. This experiment measured the optical (light) output of a nuclear detonation. Experimental equipment was located within about ten meters of ground zero. The light signal was to be transmitted to a distant detector. This system required that the experimental equipment be positioned where the levels of gamma radiation far exceeded those of any other type of radiation (56; 63).

Project 12.1, Technical Photography, was conducted by personnel from EG&G, with assistance from Navy personnel. They provided technical photography support, including dust studies,

preshock turbulence studies, light absorption and mirage studies, fireball growth measurement, thermal effects studies, and other coverage required by the Weapons Development Test Group.

Two days before the shot, project personnel prepared the film at the Control Point Building. The afternoon before Shot FOX, project personnel loaded film into remote-controlled cameras located at various stations in the ground zero area. After the detonation, EG&G personnel recovered the exposed film and processed some of it in the mobile unit set up in the Control Point area. The remaining film was flown for processing to laboratories of Consolidated Film Industries in Hollywood, California, or in the city of Fort Lee, New Jersey (42).

Project 12.1c, Bhangmeter Mod II, was conducted by EG&G. The objective was to evaluate and test a new bhangmeter. Project personnel installed these instruments, which measured the yield of a detonation, at the Control Point. Bhangmeter readings recorded at shot-time were analyzed after the shot (41).

Project 12.2a-d, High-speed Photography, was conducted by LASL and EG&G. The objectives were to study early fireball growth and obtain measurements correlating shock arrival time with the appearance of the fireball. Personnel placed cameras in a bunker 460 meters from the shot-tower and in a trailer 3,200 meters southwest of the shot-tower. After the detonation, personnel retrieved the film for analysis (38).

Program 13, Radiochemistry Sampling, involved cloud sampling conducted by personnel from the 4925th Test Group (Atomic). The sampling missions are discussed in section 3.2.3, on AFSWC activities (36).

Program 14, Test of an External Initiator, was conducted by the Los Alamos Scientific Laboratory (13).

Project 15.2, Gamma Radiation Exposure as a Function of Distance, was conducted by personnel from LASL. The objective was to measure gamma radiation exposure at various distances from the detonation. Project personnel placed gamma-detecting instruments in the ground at distances of 1,370 to 3,660 meters from ground zero. At recovery hour, two men in a vehicle entered the shot area to recover the instruments. This activity was scheduled to take 30 minutes (75).

Project 15.3, Radiation Monitoring Measurements, was conducted by LASL. The objectives were to monitor gamma radiation levels from the radioactive fallout after a nuclear detonation and to test several prototype radiation monitoring instruments for use at Operation IVY in the fall of 1952. The information on radiation levels was also used by recovery parties. Project personnel installed recording equipment in stations located about 460 meters and 1,830 meters east of ground zero. The recording equipment was set to telemeter information on gamma radiation levels to the Control Point (59).

Projects 17.1 and 17.2, External Neutron Measurements, were conducted by personnel from LASL. The objective of these projects was to use threshold detectors to measure external neutron flux as a function of distance. LASL also provided some threshold detectors to the Naval Radiological Defense Laboratory and to the Naval Research Laboratory.

Project personnel attached some threshold detectors to horizontal steel bars about four feet above the ground along a radial line 180 to 2,010 meters from the shot-tower. Other detectors were fastened to a steel cable. Participants also installed an underground shelter containing oscilloscopes set to run automatically at shot-time. After the detonation, personnel retrieved the steel cable by using a tractor to drag it out of the shot area. Other participants recovered the records from the underground shelter and retrieved the steel bars with the

threshold detectors. At Yucca Lake, the detectors were removed from the steel bars and from the cable. AFSWC courier aircraft then transported them to LASL for analysis (27).

Project 18.1, Total Thermal Radiation and Atmospheric Transmission, was conducted by the Naval Research Laboratory to obtain information on the transmission of light and thermal radiation emitted by nuclear detonations of various yields. To measure the transmission of light, project personnel placed one photoelectric brightness meter at the Control Point and another in Area 2 of the NPG. In addition, they installed a transmissometer near the BJY and a receiver at the Control Point. Participants manually operated the instruments at the Control Point during the shot. To obtain thermal radiation data, personnel installed four thermopile recorder systems and operated them from the Control Point during the shot. They shut down equipment after the detonation to analyze recorded data (60).

Project 18.4, High-resolution Spectroscopy, was conducted by the Naval Research Laboratory to supplement information obtained from spectroscopy measurements taken during earlier nuclear weapons testing series, such as Operations GREENHOUSE and BUSTER-JANGLE. Project personnel installed a spectrometer at the Control Point, located almost 19 kilometers south of the FOX ground zero. The procedures for this experiment have not been documented, but project personnel probably operated the spectrograph manually through shot-time and shut down the instrument shortly after the detonation to process and analyze the data recorded (16).

Projects 19.1c and 19.d, Shock-gauge Evaluations Tests, were conducted by Sandia Laboratory. Personnel from LASL and contractors assisted in calibrating and installing instruments. The project was intended to develop and test new instruments for measuring dynamic and static pressures, wind directions, sound and wind speeds, and temperature rises resulting from a shock

wave. Project personnel installed instruments at a station 790 meters from ground zero. Cables connected the instruments to equipment that recorded the information (26).

3.2.3 Air Force Special Weapons Center Activities

The Air Force Special Weapons Center provided personnel to staff the Air Operations Center, located at the Control Point. AFSWC also conducted cloud sampling and sample courier missions for the test groups and cloud tracking and aerial radiological surveys of the terrain for the Test Manager. In addition, Strategic Air Command personnel witnessed the detonation. Although the SAC observers were not part of AFSWC, they are discussed in this section because they were under the operational control of AFSWC while over the NPG (1-3; 5; 36; 37; 52; 69).

The following listing indicates the types and numbers of aircraft and the estimated numbers of personnel involved in missions at Shot FOX:

TITLE	TYPE OF AIRCRAFT	NUMBER OF AIRCRAFT	NUMBER OF PERSONNEL
Sampling			
Sampler Control	B-29	1	9
Sampler	T-33	4	8
Sampler	F-84	6	6
Sampler	B-29	1	8
Sampler Courier Service			
	B-25	3	15
	C-47	1	4
Cloud Tracking	B-25	1	5
	B-29	1	10
Aerial Surveys of Terrain	C-47	2	10
	L-20	2	2
Observer Activities	B-50	9	108

Cloud Sampling

One B-29, four T-33s, and six F-84s collected particulate and gaseous samples of the Shot FOX cloud for Project 7.3, Radiochemical and Physical Analysis of Atomic Bomb Debris, and for Program 13, Radiochemistry Sampling. The sampler control aircraft, with an AFSWC aircrew and a LASL scientific advisor onboard, directed the operations of the sampler aircraft. The sampler aircraft flew at altitudes of 30,000 to 40,000 feet and made a total of 35 penetrations of the cloud. The following listing details their activities (1-3; 36; 37; 52; 69):

AIRCRAFT TYPE AND TAIL NUMBER	TAKEOFF TIME	TOTAL TIME IN CLOUD (seconds)	TOTAL DOSIMETER READING (roentgens)	LANDING TIME
Sampler Control B-29 (285)	0344			0918
B-29 (386)	0345	NR*	0.550	0700
T-33 (951)	0625	NR	0.550	0740
T-33 (920)	0637	NR	0.250	0815
T-33 (048)	0630	NR	0.250	0735
T-33 (913)	0645	NR	0.215	0910
+F-84 (834)	0408	NR	0.140	0445
F-84 (030)	0711	NR	0.100	0820
F-84 (791)	0746	NR	0.085	0900
F-84 (846)	0753	NR	0.005	0910
F-84 (782)	0805	NR	NR	0945
F-84 (717)	0900	NR	0.050	0930

*NR indicates not reported.

+The six F-84 sampler aircraft were part of Task Group 132.4. These pilots were gaining experience in sampling techniques for their participation in Operation IVY in the fall of 1952.

Upon completion of their mission, the samplers returned to Indian Springs AFB and parked in the northeast corner of the parking area. Pilots then shut down the engines. The crews of the B-29s left the aircraft through the rear door between the stabilizer and the wing. The crews of the T-33s and F-84s disembarked by stepping onto a boarding ladder attached to the side of the aircraft. The sample-removing team and radiological safety monitors used long-handled tools to take samples from the aircraft and place them in shielded containers. They used the same method to remove the bottles containing the gaseous samples. They then loaded the sample containers onto courier aircraft for delivery to AEC laboratories for analysis (1-3; 36; 37; 52; 69).

Courier Missions

After the sampling missions had been completed, three B-25 and one C-47 aircraft left Indian Springs AFB and Yucca Lake airstrip on shot-day to transport samples and filter papers to various laboratories for analysis. The 4901st Support Wing (Atomic) conducted these courier missions.

At an unreported time, a B-25 flew from Indian Springs AFB to McClellan AFB with Project 7.3 samples. At 0800 hours, a C-47 flew from Indian Springs AFB to LASL with Program 13 samples. At about 0800 hours, a B-25 left Yucca Lake airstrip for LASL with Project 17.1 samples. At an unspecified time, a B-25 flew from Indian Springs AFB to the Army Chemical Center with Project 6.3 samples (1-3; 36; 37; 52; 69).

Cloud Tracking

Soon after the shot, one B-25 and one B-29 from Indian Springs AFB flew cloud-tracking missions over and beyond the NPG. The B-25 (tail number 099) took off at 0418 hours, tracked the cloud at altitudes ranging from 5,000 to 16,000 feet, and landed at 0805 hours. The B-29 (tail number 826) took off at 0415 hours, tracked the cloud at altitudes of 22,000 to 24,000 feet, and landed at 1018 hours (1-3; 36; 37; 52; 69).

Aerial Surveys of Terrain

After the detonation, two C-47 and two L-20 aircraft, based at Indian Springs AFB, conducted radiological surveys of the onsite and offsite terrain. The following list summarizes the times and heights of the missions (1-3; 36; 37; 52; 69):

AIRCRAFT TYPE AND TAIL NUMBER	DEPARTURE TIME	HEIGHT (feet)	LANDING TIME
C-47 (386)	0625	300-7,000	0840
C-47 (308)	NR*	10,000	NR
L-20 (464)	NR	200-10,000	NR
L-20 (467)	0927	50-200	1125

*NR indicates not recorded.

Observer Activities

Nine B-50 aircraft from the Strategic Air Command participated in an orientation and indoctrination exercise in nuclear weapons effects. On shot-day, the B-50s, possibly from Biggs AFB, El Paso, Texas, with SAC observers aboard entered the Nevada Proving Ground area between 0156 and 0340 hours. The aircraft remained in an orbiting pattern through shot-time so that the observers could witness the detonation and subsequent cloud development. At 0405 and 0407 hours, all aircraft left the test area (1-3; 5; 36; 37; 52; 69).

3.3 RADIATION PROTECTION AT SHOT FOX

The primary purpose of the radiation protection procedures developed for participants in Exercise Desert Rock IV, the test groups, and AFSWC for Operation TUMBLER-SNAPPER was to keep individual exposure to ionizing radiation to a minimum, while still allowing participants to accomplish their missions.

3.3.1 Desert Rock Radiation Protection Activities

Personnel in the FOX observer program witnessed the detonation from trenches 11 kilometers from ground zero. The Desert Rock Radiological Safety Group devised plans and supplied personnel for radiation protection activities. Although the Army generally conducted these activities under the supervision of AFSWP monitors, Desert Rock monitors were permitted to survey the approach route to the display area without the supervision of AFSWP monitors. This was the first time in Operation TUMBLER-SNAPPER that Desert Rock monitors operated without AFSWP supervision (43; 51).

Orientation and Briefing

The indoctrination course, covering personal protection procedures and medical effects, as well as basic characteristics of nuclear weapons, was conducted from 12 to 24 May. The course was extended because adverse weather conditions and mechanical problems delayed the FOX detonation. For the first time in the series, members of the Instructor Group were from AFSWP. At the two previous shots with Desert Rock activities, instructors had not been familiar with the material that they presented (15; 51).

Dosimetry and Protective Equipment

The Signal Section issued film badges, which were supplied and processed by the AFSWP Radiological Safety Group, and the Quartermaster Section issued field protective masks to all participants. At the indoctrination course, all personnel were instructed to place their film badges in their left breast pocket, with the numbers on the badge facing outward from the body. In addition, participants were instructed in the proper use of their field protective masks, which were to be worn if the command was given to evacuate the area (49; 51).

Monitoring

Following the detonation, Desert Rock monitors surveyed the approach route to the equipment display area. These monitors, unaccompanied by AFSWP monitors, noted radiation intensities along the route and located and marked the 0.5 R/h line, the forward limit for troops. After the monitors had surveyed the display route and AFSWP monitors had completed the survey of the rest of the shot area, the Test Manager declared the area safe to enter. Desert Rock monitors accompanied the troops as they moved up to and through the equipment display area (49; 51).

Decontamination

Personnel were brushed with brooms to remove contaminated dust when they returned from the trench area. Monitors then checked all personnel with AN/PDR-T1B meters. Those individuals whose readings could not be reduced to less than 0.01 R/h were ordered to the decontamination station at Yucca Pass to shower and change into clean clothing. Monitors checked these individuals after they had showered to ensure that intensities on their skin were less than 0.0015 R/h (49; 51).

Vehicles were also monitored and sent to the decontamination station if brushing could not reduce their level of contamination to less than 0.01 R/h (49; 51).

3.3.2 Joint AEC-DOD Radiation Protection Activities

Information on Shot FOX has been obtained from the radiological safety report prepared by AFSWP (43). The document includes data on radiological safety equipment, onsite and offsite monitoring procedures, and radiation isointensity contour maps.

Logistics and Materiel

During the period 25 through 31 May 1952, which covers the 25 May detonation of Shot FOX, the Logistics and Materiel Department issued film badges to about 340 AEC and DOD personnel involved in test group activities. The department also issued 549 sets of protective clothing and 260 radiation survey meters (43).

Monitoring

Initial ground survey monitors began recording radiation intensities at 0512 hours, slightly more than one hour after the detonation. They continued their survey until 0645 hours, approaching as close as 460 meters north of ground zero, where the radiation intensity was 10.0 R/h. Initial survey monitors, however, could not survey the area to the northeast of ground zero because of radiation levels in excess of 10.0 R/h. Monitors conducted resurveys on subsequent days. Part of the FOX radiation overlapped the residual radiation from Shot EASY, as indicated by the radiation contours to the south-southeast of ground zero (43).

Significant fallout also occurred northeast of the NPG, particularly in the area of Groom Mine, Nevada, about 30 kilometers from ground zero, where the highest recorded intensity was 0.32 R/h, seven hours after the detonation.

Eight to 13 two-man mobile teams participated in the offsite monitoring. About six hours before the detonation, they left the test area for assigned offsite locations.

In addition to the ground survey teams, two C-47s and two L-20s conducted offsite surveys of the terrain. The C-47 aircraft measured radiation intensities of up to 0.03 R/h approximately 75 kilometers northeast of ground zero. The highest radiation intensity encountered by the L-20s was 0.0025 R/h (43).

Plotting and Briefing

Ground monitoring teams provided survey data for the isointensity plots. Plotting and Briefing personnel consolidated these data to make the initial isointensity plot, a copy of which is shown in figure 3-3. Copies of the isointensity maps generated from resurveys are shown in figure 3-4 (43). The labels of the maps in the source document do not always reflect the range of survey times given in the tables of intensity readings that accompany the maps.

Dosimetry Data

Seven AFSWP participants who were issued film badges for the period 25 to 31 May 1952 accumulated exposures between 3.0 and 6.0 roentgens (43).

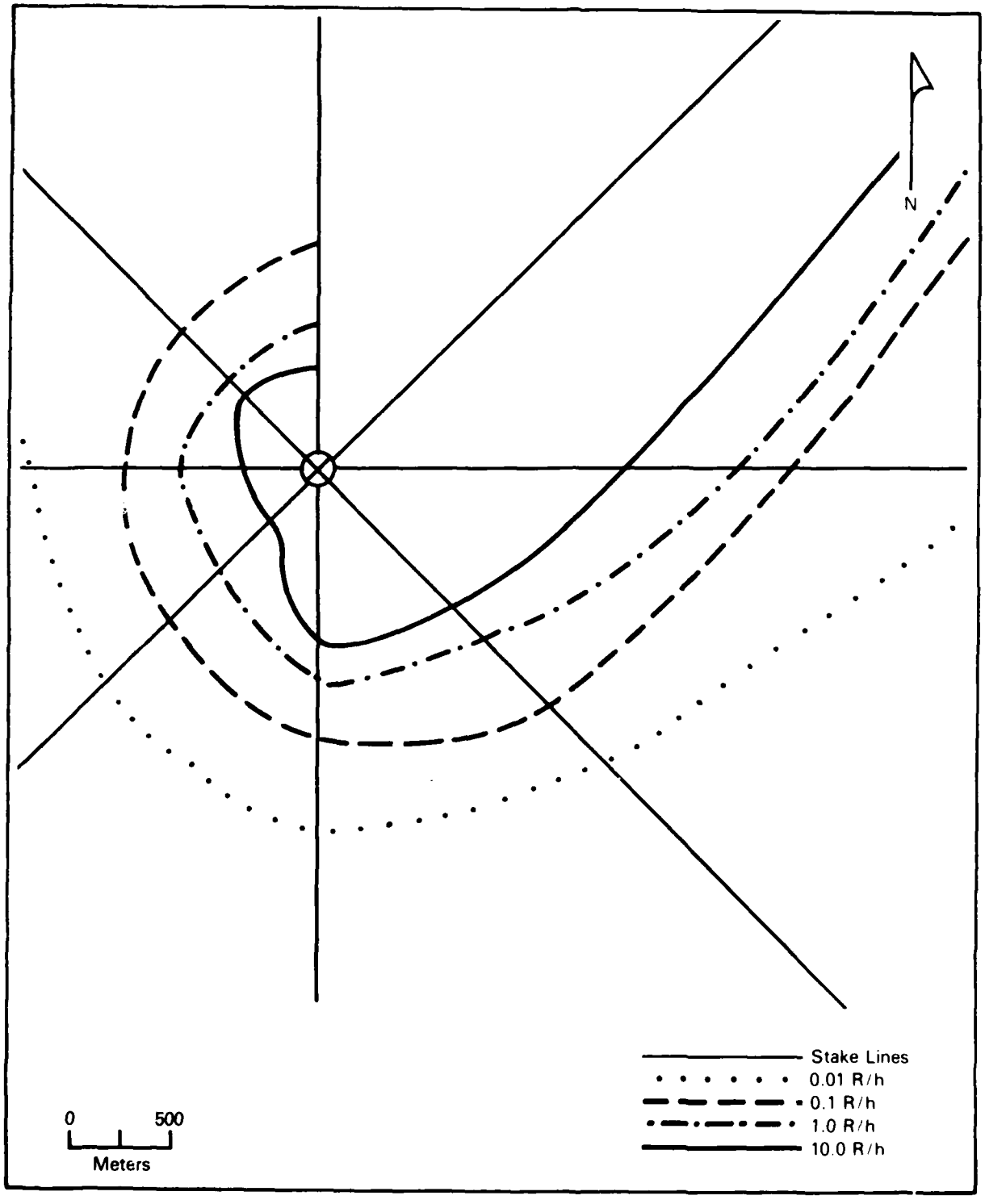


Figure 3-3: INITIAL RADIATION ISOINTENSITY MAP FOR SHOT FOX, 25 MAY 1952, 0530 HOURS

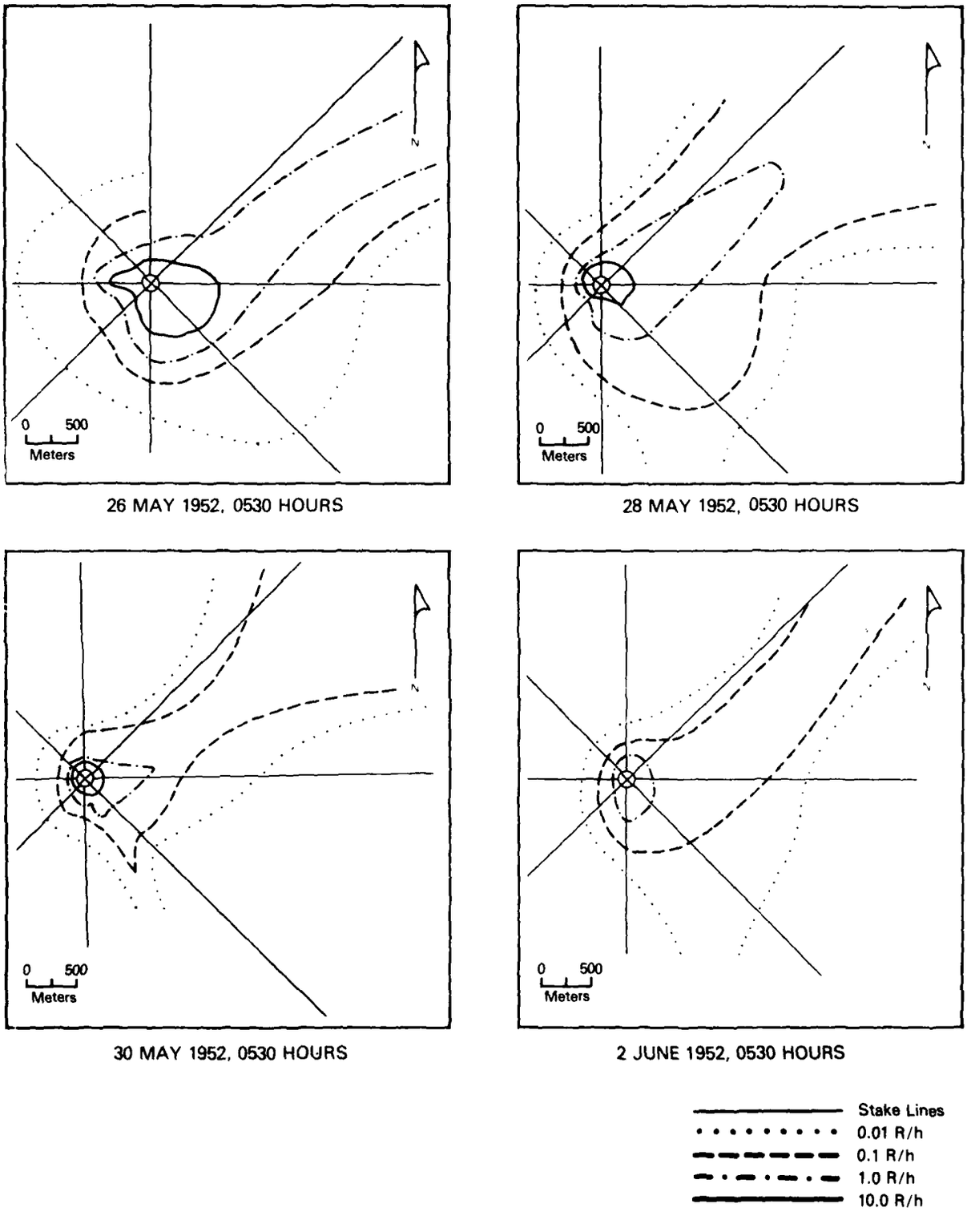


Figure 3-4: SUBSEQUENT RADIATION ISOINTENSITY MAPS FOR SHOT FOX

SHOT GEORGE SYNOPSIS

AEC TEST SERIES:	TUMBLER-SNAPPER
DOD EXERCISE:	Exercise Desert Rock IV
DATE/TIME:	1 June 1952, 0355 hours
YIELD:	15 kilotons
HEIGHT OF BURST:	300 feet (tower)

DOD Objective: To determine the military value of weapons effects for offensive and defensive deployment.

Weather: At shot-time, the surface winds were calm. Winds were 15 knots from the south-southeast at 10,000 feet, 44 knots from the south at 20,000 feet, and 36 knots from the south at 30,000 feet. The temperature was 11°C, the relative humidity was 48 percent, and the pressure was 872 millibars.

Radiation Data: The initial radiation survey established the 0.01 R/h line about 1.3 kilometers to the west, south, and east of ground zero at 0530 hours. The area north of ground zero could not be surveyed on shot-day because of radiation levels in excess of 10.0 R/h.

Participants: Exercise Desert Rock IV troops; Armed Forces Special Weapons Project; Air Force Special Weapons Center; Atomic Energy Commission; Los Alamos Scientific Laboratory; contractors.

CHAPTER 4

SHOT GEORGE

Shot GEORGE, the seventh test of Operation TUMBLER-SNAPPER, was a weapons development test and thus part of the SNAPPER phase of the operation. Developed by the Los Alamos Scientific Laboratory, the nuclear device was detonated on a 300-foot tower at 0355 hours Pacific Standard Time on 1 June 1952. First scheduled for 20 May, the shot had been postponed because of adverse weather. The original plans called for Shot GEORGE to be detonated in Area 2, but residual radioactivity from Shots EASY and FOX delayed preparation of the area. Consequently, the Test Manager decided to detonate GEORGE in Area 3, UTM coordinates 871004, and use Area 2 for Shot HOW. Consequently, the Desert Rock activities originally scheduled for Shot HOW were rescheduled for Shot GEORGE (1; 2; 30; 40; 67; 74).

The top of the Shot GEORGE cloud reached an altitude of 37,000 feet. At 30,000 feet, the winds were from the south at 36 knots. The cloud drifted north from the point of detonation (40).

4.1 EXERCISE DESERT ROCK IV OPERATIONS AT SHOT GEORGE

About 1,300 Army maneuver troops, consisting of Camp Desert Rock support troops, participated in Desert Rock IV programs at Shot GEORGE. In addition, approximately 500 Army troops from various service schools and commands took part in the observer program at this shot (23; 51).

4.1.1 Participation of Camp Desert Rock Support Troops

The Camp Desert Rock units that performed the tactical maneuver included the 23rd and 31st Transportation Truck Companies and the following elements of the 369th Engineer Amphibious Support Regiment:

- Headquarters and Headquarters Service Company
- Headquarters and Headquarters Company Shore Battalion
- D, E, and F Companies.

The Desert Rock Radiological Safety Group and the Instructor Group were the Exercise Desert Rock IV staff sections most involved in shot-day operations. The Desert Rock Radiological Safety Group enforced radiological safety criteria and conducted radiation surveys. One important postshot function of this group was a survey of the shot area, conducted by Army Chemical, Biological, and Radiological survey teams. The CBR teams moved both ahead of and with the attacking troops.

The Instructor Group led the maneuver units through the display area to view the damage caused by the burst. The instructors noted differences between the predicted and actual effects.

In addition to the Instructor Group and the Desert Rock Radiological Safety Group, several other Desert Rock support elements participated at GEORGE.

Before the shot, personnel from the 369th Engineer Amphibious Support Regiment spent several days preparing the equipment display area by placing military vehicles and ordnance at various distances from ground zero. Exercise troops examined the condition of these displays before and immediately after the detonation.

The 23rd and 31st Transportation Truck Companies transported military personnel to and from the forward area. The 23rd provided transportation for observers, while the 31st transported the 369th Engineer Amphibious Support Regiment. At shot-time, vehicles from the 23rd and 31st Truck Companies were parked south of the trench area.

The Camp Desert Rock Signal Detachment established wire and radio communications in the forward area, as well as at Camp Desert Rock. The detachment operated the mobile public address systems in the display area after the shot to assist the Instructor Group in its presentations.

The Camp Desert Rock Medical Detachment provided medical support in the forward area during the Desert Rock maneuver. A medical officer and three aidmen established an aid station in the truck parking area, just south of the trenches.

Company A, 505th Military Police Battalion, controlled Desert Rock vehicles moving in the forward area on shot-day. Military police were stationed at all gates, junctions, and checkpoints along the route to the shot area. They also accompanied convoys to the forward area. Approximately 58 military policemen participated at Shot GEORGE (50; 51).

4.1.2 Troop Observer Activities

Observer activities at Shot GEORGE involved about 500 Army personnel. These observers included Camp Desert Rock personnel and officials and personnel from various Continental Army commands and service schools throughout the United States.

All observers took part in the same orientation and training activities. Most observers arrived at Camp Desert Rock between 16 and 19 May, but the nuclear test was delayed until 1 June.

The week before the detonation, the observers rehearsed their shot-day activities, including an inspection of the equipment display area, shown in figure 4-1. The Instructor Group provided the observers with an orientation, consisting of films and lectures on the characteristics of a nuclear detonation and the procedures to follow during a detonation. When GEORGE was postponed for ten days, the Instructor Group presented additional information to the observers (23; 50; 51).

At about 0100 hours on 1 June, the observers, wearing fatigues, combat boots, fatigue caps, field jackets, cartridge belts, and canteens, left Camp Desert Rock for the trench area, which they reached by about 0230 hours. The Instructor Group then conducted the preshot orientation. Ten minutes before shot-time, the observers were directed to enter the trenches to witness the shot. The trenches were 6,400 meters south of ground zero (51; 63).

Ten minutes after recovery hour was declared, the observers traveled by truck to the equipment display areas, extending 3,200 meters southwest of ground zero. They returned to Camp Desert Rock after approximately six hours in the forward area (51; 63).

4.1.3 Tactical Troop Maneuver

An estimated 1,300 personnel took part in the maneuver at Shot GEORGE, the last Army maneuver in Operation TUMBLER-SNAPPER. The objectives of the maneuver were to (15; 50; 51):

- Provide training in the tactical employment of a nuclear weapon
- Provide training in essential protective measures
- Determine psychological reactions of participating troops

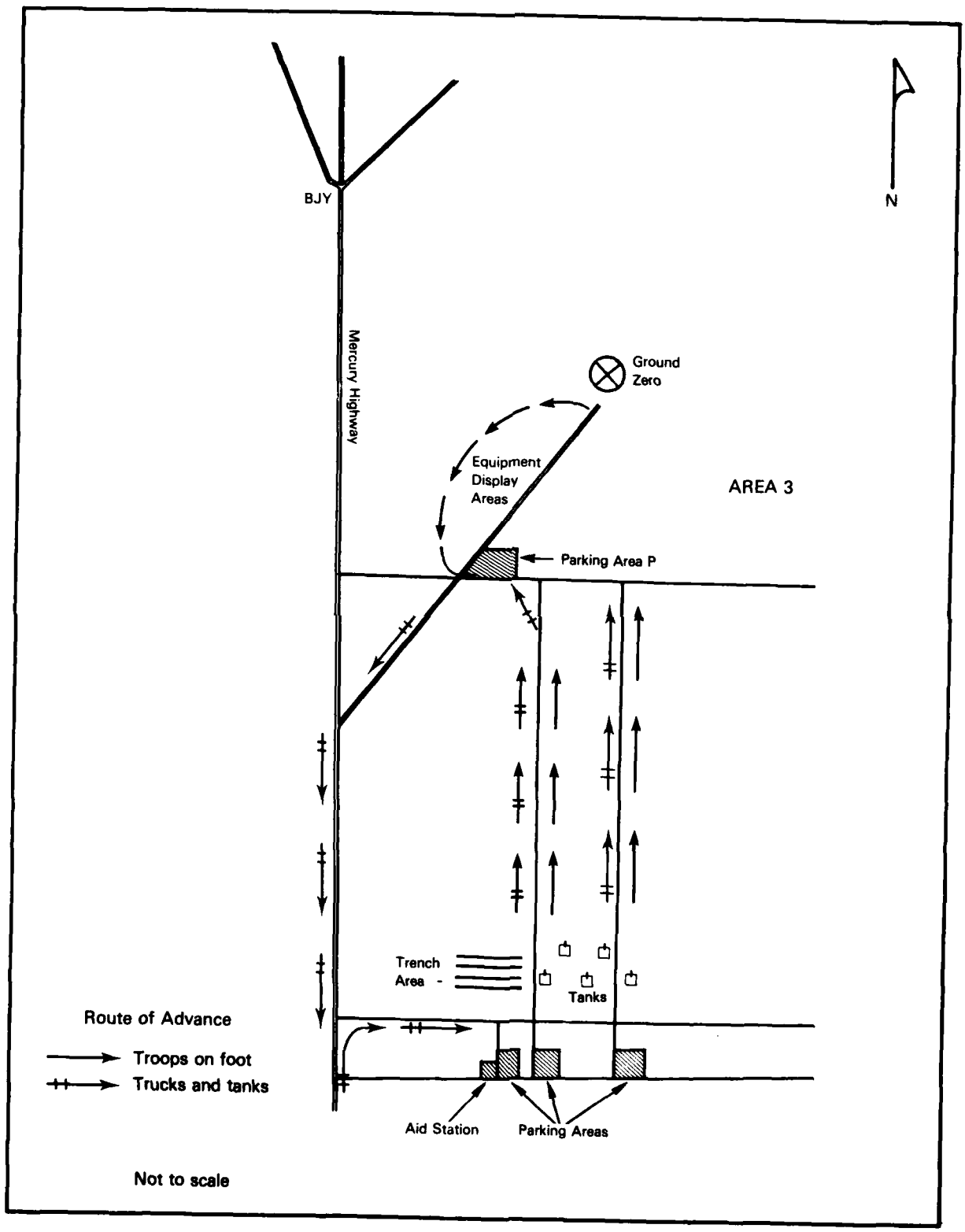


Figure 4-1: TRENCHES, EQUIPMENT DISPLAY AND PARKING AREAS, AND ROUTES OF ADVANCE FOR EXERCISE DESERT ROCK IV ACTIVITIES AT SHOT GEORGE

- Determine the effects of the detonation on military equipment located at various distances from ground zero.

Camp Desert Rock support units provided most of the participants for this maneuver. Participating troops included the 23rd and 31st Transportation Truck Companies and elements of the Shore Battalion of the 369th Engineer Amphibious Support Regiment. These units, in camp since the beginning of the Desert Rock IV exercises in April, provided logistical support for the earlier Desert Rock maneuvers. A tank platoon of the 1st Armored Division, which was not a Camp Desert Rock support unit, also took part in the maneuver (51).

The tactical troop maneuver at Shot GEORGE was a ground assault toward an objective near ground zero. The Army developed this troop maneuver according to the following scenario. An aggressor with overwhelming forces had invaded the northwestern United States and launched an offensive attack eastward to conquer the entire country. Friendly forces wanted to force the aggressor into conducting an all-out mass attack so that its main forces could be drawn into the open. The aggressor had advanced to a line of strong defensive positions in Yucca Flat, near the ground zero area, and was readying itself to launch another attack. In the meantime, friendly forces were entrenched south of ground zero and were preparing to counterattack with a nuclear weapon, fired from a 280-millimeter cannon. The shot would destroy most of the aggressor force. The 1st Armored Division and the 31st and 44th Infantry Divisions were then to attack and destroy the remaining aggressor force in the area (51).

Troops of the 369th Engineer Amphibious Support Regiment were attached to the 1st Armored Division for this exercise. At shot-time, this regiment was to occupy prepared positions in Yucca Flat, 6,400 meters from ground zero. Immediately following

the nuclear detonation and passage of the shock wave, the regiment was to attack on foot to secure an objective in the GEORGE shot area. Tanks from the 1st Armored Division were to lead the maneuver troops in the attack. On arriving at the objective, troops were to inspect the equipment displays.

In the days before Shot GEORGE, the Instructor Group presented an orientation for the observers and maneuver troops. The course consisted of films and lectures on the characteristics of a nuclear detonation and the procedures to follow during a nuclear test. This course was the best one conducted in Exercise Desert Rock IV since the Instructor Group was now composed of experienced AFSWP officers familiar with nuclear weapons theory and effects (51).

For Shot GEORGE, two Army contractors, the Human Resources Research Office (HumRRO) and the Operations Research Office (ORO), observed the psychological reactions of those who witnessed the detonation. Two days before the shot, HumRRO and ORO monitors interviewed and administered polygraph tests to about 30 servicemen from the 369th Engineer Amphibious Support Regiment, 31st Transportation Truck Company, 562nd Transportation Staging Area Company, and the 360th Army Band. The HumRRO and ORO teams sought to determine the psychological reactions of the participants to their upcoming participation in a nuclear event. On the day before the detonation, these same troops answered a questionnaire about nuclear combat topics and general attitudes toward the Army (17; 53; 78).

At about 0100 hours on 1 June 1952, the battalion combat teams began the trip by truck convoy to the trench area, shown in figure 4-1. The convoy reached the area at about 0230 hours, approximately 90 minutes before the detonation. Tactical troops wore fatigues, combat boots, steel helmets, field jackets, and

cartridge belts with a canteen. They carried field protective masks and individual weapons (17; 53; 78).

From 60 minutes before the detonation to about 15 minutes after shot-time, a Desert Rock instructor gave information and final instructions to the troops over the public address system. Two minutes before shot-time, he ordered all personnel to crouch in their trenches, cover their faces with their hands, lean against the forward trench wall, and remain below ground level until after the detonation (17; 51; 78).

Three seconds after the flash of light from the detonation at 0355 hours, the instructor cleared all personnel to stand up and view the fireball and cloud. Approximately 20 seconds after the shot, the blast wave reached the trench area and the resulting dust obscured vision temporarily (17; 51; 78).

In addition to the troops in the trenches, there were five tanks with crews from the 1st Armored Division in the shot area. These tanks had moved to a position just east of the trench area during the 12 hours before the detonation. The crews remained in their tanks during the detonation. Immediately after the blast wave passed, the tanks started their engines and, on orders from the Exercise Director, moved forward to attack the objective south of ground zero. Figure 4-1 shows the probable route of this maneuver (51).

Also by order of the Exercise Director and without requiring an AEC radiological safety clearance, the maneuver troops left the trenches. The troops were divided into two groups. They advanced on foot in column formation along the two roads leading to the GEORGE shot area, as shown in figure 4-1. The tanks and one 1/4-ton communications vehicle led each column. Desert Rock CBR monitors accompanied each group to the shot area (51; 74).

The troops and tanks proceeded towards ground zero until radiation intensities reached 0.5 R/h, the limit that had been agreed on by the AEC Test Manager and the Army. On reaching this limit, the troops and tanks proceeded to the parking area near the equipment display areas located within three kilometers southwest of ground zero (17; 51; 74; 78).

Available information suggests that the tank crews left their vehicles in Parking Area P and accompanied the ground troops in viewing the equipment displays. After inspecting all equipment display areas, troops and tank crews returned to Parking Area P, where they were probably monitored for radiation before they returned to Camp Desert Rock. The times when the maneuver troops and tank crews reached the display areas and returned to Camp Desert Rock are not known. However, based on similar Desert Rock IV activities at Shots CHARLIE, DOG, and FOX, troops probably boarded the trucks for the return trip to Camp Desert Rock by about 0730 hours. The trip to Camp Desert Rock by truck would have taken about 90 minutes, placing the arrival time at about 0900 hours (15; 17; 51; 74; 78).

Upon their arrival, all participants were required to shower to reduce radiation intensities, the procedure followed after the DOG maneuver. Sometime around noon of shot-day, HumRRO and ORO monitors again administered polygraph tests and questionnaires and interviewed soldiers who had taken the first tests two days before the detonation.

Upon completion of the troop maneuver at Shot GEORGE, Desert Rock IV activities ended. Temporary facilities and tents at Camp Desert Rock were dismantled, and all units returned to their home stations by the end of June 1952 (15; 17; 51; 74; 78).

4.2 DEPARTMENT OF DEFENSE PARTICIPATION IN SCIENTIFIC AND SUPPORT ACTIVITIES AT SHOT GEORGE

Department of Defense personnel took part in scientific and diagnostic projects conducted by the Military Effects Test Group and the Weapons Development Test Group. Table 4-1 lists the test group projects and identifies the participating organizations. In addition to participating in test group experiments, the Air Force Special Weapons Center provided air support to the test groups and to the Test Manager (24).

4.2.1 Military Effects Test Group Projects

The participants in the Military Effects Test Group projects at Shot GEORGE spent several weeks before the detonation placing and calibrating instruments. Project personnel usually completed these activities and left the area by the day before the detonation. Figure 4-2 shows the AFSWP instrument layout at Shot GEORGE (32).

The following project descriptions often discuss recovery operations as occurring after the announcement of recovery hour. The actual time of recovery hour was 0548 hours.

Project 2.1, Total Gamma Exposure versus Distance, was conducted by the Signal Corps Engineering Laboratories. The objective was to measure gamma radiation exposure as a function of distance. Shortly before the burst, project personnel placed National Bureau of Standards film packets at 90-meter intervals along a radial line extending 1,100 to 2,750 meters outward from the point of detonation. About two hours after recovery hour was declared, four men drove by truck into the test area to begin retrieving film packets. They recovered the film farthest from ground zero and then worked their way toward ground zero, up to the 0.1 R/h area. This task was scheduled to take three hours. Information gained from the film was eventually shared with

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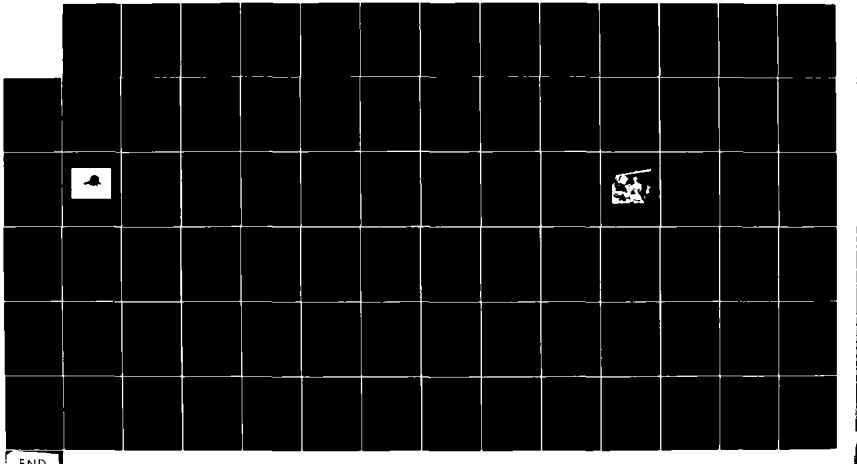

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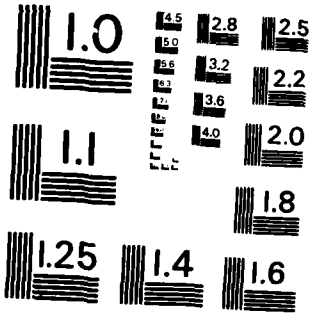


Table 4-1: TEST GROUP ACTIVITIES WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT GEORGE

Project/ Program	Title	Participants
	Military Effects Test Group	
2.1	Total Gamma Exposure versus Distance	Signal Corps Engineering Laboratories
2.2	Gamma Ray Energy Spectrum of Residual Contamination	Signal Corps Engineering Laboratories
6.1	Evaluation of Military Radiac Equipment	Bureau of Ships; Signal Corps Engineering Laboratories
6.3	Evaluation of a Filtration System for Pressurized Aircraft	Army Chemical Center
6.5	Decontamination of Aircraft	Wright Air Development Center; Naval Radiological Defense Laboratory
6.7	Evaluation of Air Monitoring Instruments	Army Chemical Center
7.1a	Electromagnetic Effects from Atomic Explosions	National Bureau of Standards; Air Force Cambridge Research Center; Air Weather Service; Geophysical Laboratory of the University of California at Los Angeles
7.1b	Long Range Light Measurements	EG&G; Headquarters, Air Force
7.2	Detection of Airborne Low-frequency Sound from Atomic Explosions	Headquarters, Air Force; Signal Corps Engineering Laboratories; National Bureau of Standards
7.3	Radiochemical and Physical Analysis of Atomic Bomb Debris	Headquarters, Air Force
7.4	Seismic Waves from A-Bombs Detonated over a Desert Valley	Air Force 1009th Special Weapons Squadron; Coast and Geodetic Survey
8.7	Thermal Radiation Measurements	Department of Engineering, University of California at Los Angeles
9.1	Technical and Training Photography	Naval Medical Research Institute; Air Force Lookout Mountain Laboratory; Wright Air Development Center; Army Pictorial Service Division; 4925th Test Group (Atomic); SAC 5th and 28th Reconnaissance Technical Squadrons; Signal Corps Engineering Laboratories
9.2	Air Weather Service Participation	Air Weather Service
9.4	Effects of Atomic Explosions on the Ionosphere	Signal Corps Engineering Laboratories; 9471st Technical Service Unit
9.5	Electromagnetic Radiation over the Radio Spectrum from Nuclear Detonations	Signal Corps Engineering Laboratories; 9467th Technical Service Unit

Table 4-1: TEST GROUP ACTIVITIES WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT GEORGE (Continued)

Project/ Program	Title	Participants
	Weapons Development Test Group	
10.2	Test of Scintillator Optical Path Technique	Naval Research Laboratory
11.1	Measurement of Transit Time	Naval Research Laboratory
12.1	Technical Photography	EG&G
12.1c	Bhangmeter Mod II	EG&G
13	Radiochemistry Sampling Program	4925th Test Group (Atomic)
14	Test of an External Initiator	Los Alamos Scientific Laboratory
15.2	Gamma Radiation Exposure as a Function of Distance	Los Alamos Scientific Laboratory
17.1 and 17.2	External Neutron Measurements	Los Alamos Scientific Laboratory
18.1	Total Thermal Radiation and Atmospheric Transmission	Naval Research Laboratory
18.3	Color Temperatures	Naval Research Laboratory
18.4	High-resolution Spectroscopy	Naval Research Laboratory
19.1c-d	Shock-gauge Evaluations Tests	Sandia Laboratory; Los Alamos Scientific Laboratory

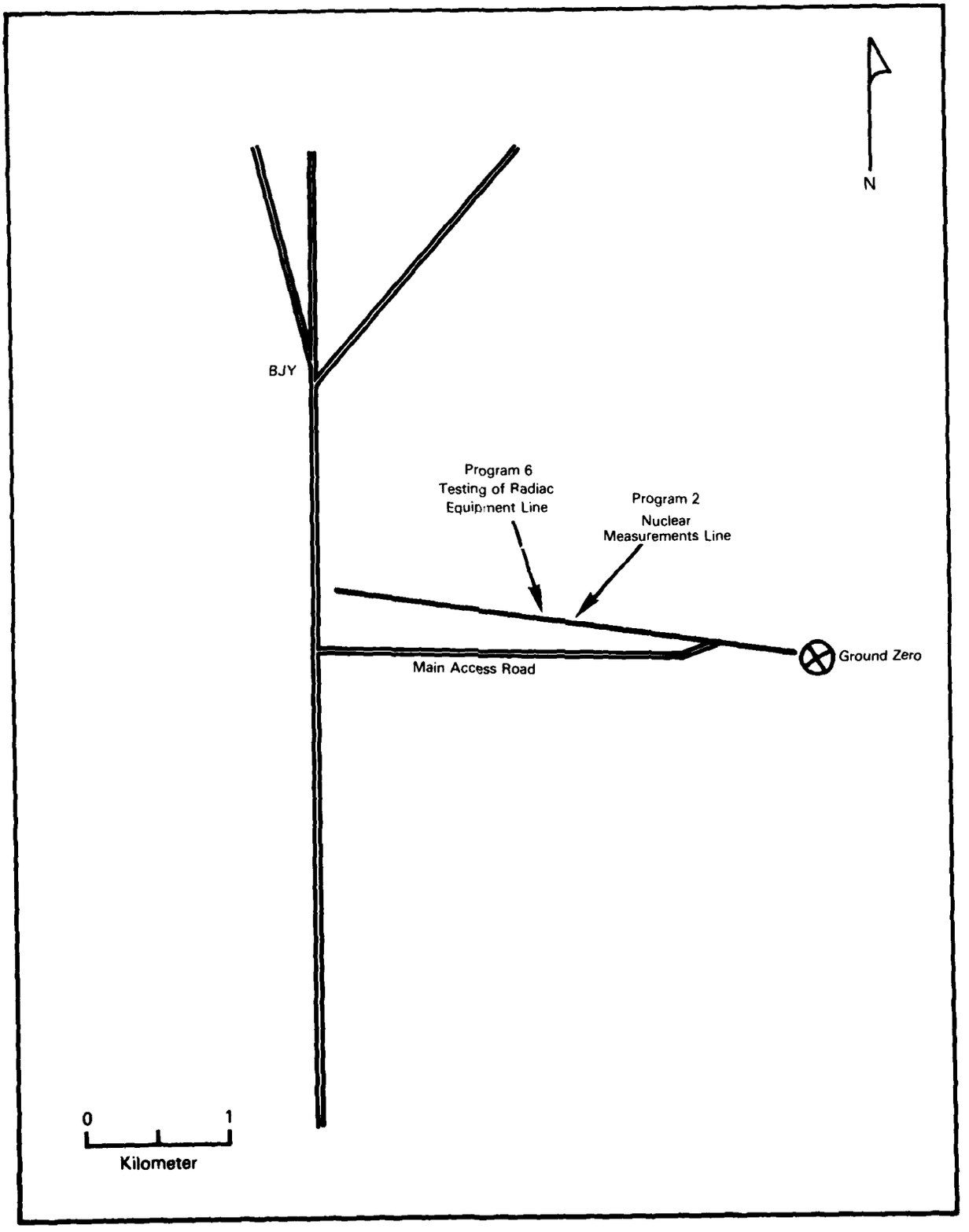


Figure 4-2: AFSWP INSTRUMENT LAYOUTS AT SHOT GEORGE

Projects 1.13, 3.1, and 6.1; the Office, Chief of Army Field Forces; and the Marine Corps (57; 63).

Project 2.2, Gamma Ray Energy Spectrum of Residual Contamination, was conducted by the Signal Corps Engineering Laboratories. The objective was to determine the relative dose contribution of various gamma radiation energies in radiation areas following a nuclear detonation. To perform this experiment, personnel used radiation survey meters that had been modified to shield portions of the gamma ray energy spectrum (77).

Before the shot, project personnel calibrated five AN/PDR-T1B radiac instruments. After the Test Manager announced recovery hour, participants placed the instruments on wooden tripods facing ground zero in the shot area. After taking readings with the instruments, they moved the equipment to other locations in the radiation field to determine any dependence of the gamma ray spectrum on distance from the point of detonation (63; 77).

Project personnel took five instrument readings on shot-day. The first was taken about three hours and 20 minutes after the burst at a distance of 570 meters from ground zero, where the intensity was 1.19 R/h, the maximum recorded that day. Soon after, four other readings were taken in the shot area at distances of 730, 890, 1,130, and 1,210 meters from the point of detonation. The last reading was taken about three hours and 45 minutes after the shot.

The following day, project personnel reentered the test area to take three additional instrument readings at distances of 480 to 970 meters from ground zero. The intensity at 480 meters was 1.29 R/h. Two days after the detonation, project personnel took four more readings at locations 400 to 730 meters from ground zero. The maximum intensity measured was 1.19 R/h, 400 meters from ground zero (63).

Project 6.1, Evaluation of Military Radiac Equipment, was conducted by the Bureau of Ships and the Signal Corps Engineering Laboratories. The objective was to evaluate radiac survey and dose-alarm equipment, dosimeters, and the instruments and techniques used for rapid aerial surveys. Project 6.1 personnel also furnished standard and experimental radiation survey instruments to other projects so that the instruments could be evaluated (72).

After the announcement of recovery hour, six project personnel in one vehicle recovered dosimeters 910 to 2,740 meters north and 80 degrees west of ground zero. Their working time was three hours. At 0900 hours on the day after the detonation, eight participants in two vehicles took new readings where the radiation intensity was 8.0 R/h. To study the techniques and instruments for the rapid aerial survey, two personnel used portable radiac meters to conduct a survey of the shot area from an LC-126 aircraft. They began their survey about 30 minutes after the detonation (63; 72).

Project 6.3, Evaluation of a Filtration System for Pressurized Aircraft, was conducted by the Army Chemical Center. The objective was to determine the adequacy of a system for filtering particulate airborne fission products from the cabin air supply of a B-29 aircraft. Shot GEORGE used the same B-29 that participated at Shot FOX (66).

Provided by the 4925th Test Group (Atomic), the B-29 aircraft staged from Indian Springs AFB. After one penetration of the Shot GEORGE cloud at an altitude of 27,500 feet, the aircraft returned to base. The filter samples were then removed from the B-29 and transported by B-25 courier aircraft to the Army Chemical Center. Courier flights are discussed in section 4.2.3 of this chapter, on AFSWC support missions. Air samples taken before and after passing through the filtering unit were compared for levels of radioactivity. The results indicated that

the filter unit removed more than 99.9 percent of the airborne fission products from the air stream entering the unit (1; 66).

Project 6.5, Decontamination of Aircraft, was conducted by the Wright Air Development Center and the Naval Radiological Defense Laboratory. The project was designed to investigate methods of reducing the radiation exposure of maintenance and flight crews.

To study adhesion of contamination to differently treated surfaces, project personnel prepared various parts of two T-33A aircraft by treating with acid, polishing, oiling, or using combinations of these methods. Five Air Force personnel, wearing protective clothing, film badges, and pocket dosimeters, surveyed each aircraft as soon as it landed after completing the cloud sampling missions described in section 4.2.3. Using AN/PDR-T1B instruments, they surveyed radiation intensities at 32 locations on the aircraft before and after decontamination. Aircraft were considered decontaminated when intensities were less than 0.02 R/h.

For the second part of this project, participants measured radiation levels inside the cockpits of a T-33A and two F-84G aircraft. These aircraft had not been used in the first part of the project. With these measurements, they evaluated the contributions of various aircraft sections to exposure rates inside the cockpit (76).

Project 6.7, Evaluation of Air Monitoring Instruments, was conducted by the Army Chemical Center. The objective was to determine the adequacy of a Chemical Corps air sampler for radiological air monitoring. Before the shot, project personnel placed six air samplers at each of four stations, positioned in the areas of expected fallout. Project personnel recovered the instruments eight hours after the detonation. The radiation level at a station 8.2 kilometers north-northwest of ground zero

was 5.0 R/h at the time of recovery. The level at the station 8.8 kilometers north-northwest of ground zero was 1.2 R/h. At two stations 7.7 and 8.5 kilometers north-northeast of ground zero, the radiation intensity was at background levels (45; 63).

Project 7.1a, Electromagnetic Effects from Atomic Explosions, was conducted by the National Bureau of Standards, Air Force Cambridge Research Center, Air Weather Service, and the Geophysical Laboratory of the University of California at Los Angeles. The project was designed to study at onsite and offsite stations the electromagnetic pulses produced by a nuclear detonation. Data were evaluated as a means of determining the location of distant nuclear detonations. The onsite stations were at Frenchman and Yucca Flats, and the offsite stations in Colorado, Florida, Georgia, Massachusetts, New Mexico, Virginia, Bermuda, Germany, and Puerto Rico (64).

Three hours before the detonation, four project personnel in two vehicles left the Control Point area to occupy the onsite stations. One participant proceeded to a station 1.6 kilometers south of the Control Point, while the remaining three personnel traveled to Station 460 at Yucca Lake (63; 64).

Project 7.1b, Long Range Light Measurements, was conducted entirely offsite by EG&G and Headquarters, Air Force. The objective was to gain information on the long-range detection of light produced by a nuclear detonation. EG&G and the Air Force established light-detecting stations in Arizona, Idaho, Texas, and Washington. An estimated two EG&G employees and ten Air Force personnel from the Sacramento Air Materiel Area, McClellan AFB, operated each station from about six hours before to one hour after the detonation (35).

Project 7.2, Detection of Airborne Low-frequency Sound from Atomic Explosions, was conducted by Headquarters, Air Force, with

assistance from the Signal Corps Engineering Laboratories and the National Bureau of Standards. The objective was to determine the accuracy of long-range acoustic detection methods. The Signal Corps Engineering Laboratories operated stations in Alaska, Hawaii, Kentucky, New Jersey, Texas, and Washington. The National Bureau of Standards operated a station in Washington, D.C. (65).

Project 7.3, Radiochemical and Physical Analysis of Atomic Bomb Debris, was conducted by Headquarters, Air Force. The project, which involved analysis of particulate and gaseous samples from the Shot GEORGE cloud, was conducted in conjunction with Program 13, Radiochemistry Sampling. Cloud sampling, performed by the 4925th Test Group (Atomic) of Kirtland AFB, is discussed in section 4.2.3 of this chapter (71).

Project 7.4, Seismic Waves from A-Bombs Detonated over a Desert Valley, was conducted by the Air Force 1009th Special Weapons Squadron and the Coast and Geodetic Survey. The objective was to determine the seismic properties of the geological structure of the test area. At 0900 hours on the day after the detonation, two project participants in a jeep went to the tower area to recover seismic records from Stations 7.2a South and 7.2a North. On the second day after the detonation, they retrieved records from a station 910 meters from ground zero. At 0900 hours on the third day after the detonation, participants began recovering records from a station 310 meters from ground zero (20; 63).

Project 8.7, Thermal Radiation Measurements, was performed by the UCLA Department of Engineering, under contract to the Air Research and Development Command. The project was designed to train Department of Engineering personnel in the use of thermal radiation measuring instruments being developed for Operation

IVY. Another objective was to collect data on the thermal radiation emitted from nuclear tests. Data on thermal radiation were recorded at Building 400, 13 kilometers from ground zero, near the Control Point (63; 70).

Project 9.1, Technical and Training Photography, was conducted by personnel from the following agencies (63):

- Air Force Lookout Mountain Laboratory
- Army Pictorial Service Division
- Naval Medical Research Institute
- Signal Corps Engineering Laboratories
- SAC 5th Reconnaissance Technical Squadron
- SAC 28th Reconnaissance Technical Squadron
- Wright Air Development Center
- 4925th Test Group (Atomic).

Project 9.1 personnel photographed Shot FOX from the ground and from the air. Lookout Mountain Laboratory personnel in a C-47 aircraft took aerial photographs. The C-47, which left Indian Springs AFB at about 0327 hours, was at an altitude of about 10,000 feet at shot-time. Participants photographed the detonation and the resulting cloud formation until 0400 hours, when they left the area and returned to Indian Springs AFB. They reached base at 0416 hours (36; 63).

At the announcement of recovery hour, two photographers with a vehicle joined the Desert Rock observers in the trench area. This group stayed with the observers during the remainder of Desert Rock operations on shot-day. Project 9.1 personnel also took still photographs and motion pictures of various Military Effects Test Group projects (63).

Project 9.2, Air Weather Service Participation, involved Air Force personnel, who compiled data from various weather stations at the NPG and offsite, prepared weather maps, and briefed NPG

officials on current and predicted weather conditions. Project participants were from the 6th Weather Squadron (Mobile) of the 2059th Air Weather Wing, Tinker AFB, Oklahoma. These personnel were deployed as follows (54):

- Eight forecasters, 13 weather observers, and two equipment operators at the Control Point Weather Station near Yucca Pass
- Twelve airmen from the Rawinsonde Weather Observation Section at the Control Point and 11 airmen at a station in Tonopah, Nevada
- Three airmen from the Pibal Weather Observation Section at Beatty, Caliente, Crystal Springs, Currant, and Warm Springs, Nevada, and St. George, Utah.

Before Shot GEORGE, project participants installed wind and humidity measuring instruments at two stations along the blast line 910 and 1,830 meters from ground zero. From about eight to three hours before the detonation, two project participants checked the instruments in the shot area on an hourly basis. About four hours after the announcement of recovery hour, two project participants began retrieving records from the two stations, a procedure that took two hours. On the day after the detonation, project personnel reentered the shot area to complete recovery operations (54; 63).

Project 9.4, Effects of Atomic Explosions on the Ionosphere, was conducted by the Signal Corps Engineering Laboratories, with assistance from personnel of the 9471st Technical Service Unit. The objective was to obtain data on the effects of a nuclear detonation on ionospheric radiowave propagation.

Project personnel worked at transmitter and receiver stations. The only onsite facility was a transmitter at Station 9.4, 910 meters north of the Control Point. Two other transmitters were at Mather AFB, Sacramento, California. The radio receiver stations were at the Navaho Ordnance Depot, Flagstaff, Arizona; White Sands Proving Ground, New Mexico, and Fort Sill, Oklahoma.

On the day before the shot, project personnel practiced operating the transmitters and receivers. On shot-day, four participants operated instruments from one hour before to one hour after the detonation. All information obtained at the project stations was sent for analysis to the Signal Corps Engineering Laboratories (28).

Project 9.5, Electromagnetic Radiation over the Radio Spectrum from Nuclear Detonations, was conducted by the Signal Corps Engineering Laboratories, assisted by the 9467th Technical Service Unit, Electronic Warfare Center. The project was designed to determine the wave shape and amplitude of radio-frequency energy emanating from a nuclear detonation.

Project personnel operated two stations 15 to 25 kilometers from ground zero through the detonation. In addition, project participants manned one station at White Sands Proving Grounds in New Mexico and another at the Evans Signal Laboratory in Belmar, New Jersey (19).

4.2.2 Department of Defense Participation in Weapons Development Test Group Projects

Although most of the Weapons Development Test Group activities were performed by agencies under contract to the Atomic Energy Commission, some of the projects were conducted by DOD agencies. For example, the Naval Research Laboratory performed all of the experiments for Program 18, Thermal Measurements. In addition, a few DOD personnel were assigned to LASL or to the Weapons Development Test Group to assist in the projects listed in table 4-1.

Project 10.2, Test of Scintillator Optical Path Technique, was performed by the Naval Research Laboratory to evaluate experimental equipment for use at Operation IVY. This experiment measured the optical (light) output of a nuclear detonation.

Experimental equipment was located within about ten meters of ground zero, and the light signal was to be transmitted to a distant detector. This system required that the experimental equipment be positioned where the levels of gamma radiation far exceeded those of any other type of radiation (56).

Project 11.1, Measurement of Transit Time, was conducted by the Naval Research Laboratory. After the detonation, five project personnel in two vehicles entered the tower area to recover film from shelters located at stations 1,000 and 900 meters west of ground zero. Their working time was one hour. At 0800 hours on the day after the detonation, five project personnel in two vehicles went to stations 980 and 920 meters west of ground zero. Their working time was three hours (55; 63).

Project 12.1, Technical Photography, was conducted by personnel from EG&G, with assistance from Navy personnel. They provided technical photography support, including dust studies, preshock turbulence studies, light absorption and mirage studies, fireball growth measurement, thermal effects studies, and other coverage required by the Weapons Development Test Group.

Two days before the shot, project personnel prepared the film at the Control Point Building. The afternoon before Shot GEORGE, project personnel loaded film into remote-controlled cameras located at various stations in the ground zero area. After the detonation, EG&G personnel recovered the exposed film and processed some of it in the mobile unit set up in the Control Point area. The remaining film was flown to laboratories of Consolidated Film Industries in Hollywood, California, or in the city of Fort Lee, New Jersey, for processing (42).

Project 12.1c, Bhangmeter Mod II, was conducted by EG&G. The objective was to evaluate and test a new bhangmeter. Project personnel installed these instruments, which measure the yield of

a detonation, at the Control Point. Bhangmeter readings recorded at shot-time were analyzed after the shot (41).

Program 13, Radiochemistry Sampling, involved cloud-sampling, conducted by personnel from the 4925th Test Group (Atomic). The sampling missions are discussed in section 4.2.3, on AFSWC activities (36).

Program 14, Test of an External Initiator, was conducted by the Los Alamos Scientific Laboratory (13).

Project 15.2, Gamma Radiation Exposure as a Function of Distance, was conducted by personnel from LASL. The objective was to measure gamma radiation exposure at various distances from the detonation. Project personnel placed gamma-detecting instruments in the ground at distances of 1,290 to 3,480 meters from ground zero. After recovery hour, four men in two vehicles entered the shot area to recover the instruments. They were scheduled to work in the area for one hour (75).

Projects 17.1 and 17.2, External Neutron Measurements, were conducted by personnel from LASL. The objective of these projects was to use threshold detectors to measure external neutron flux as a function of distance. LASL also provided some threshold detectors to the Naval Radiological Defense Laboratory and to the Naval Research Laboratory.

Project personnel attached some threshold detectors to horizontal steel bars about four feet above the ground along a radial line 180 to 2,010 meters from the shot-tower. Other detectors were fastened to a steel cable. Project participants also installed an underground shelter containing oscilloscopes set to run automatically at shot-time. After the detonation, project personnel retrieved the steel cable by using a tractor to drag it out of the shot area. Other participants recovered the records from the underground shelter and retrieved the steel bars with

the threshold detectors. At Yucca Lake, the threshold detectors were removed from the bars and from the cable. AFSWC courier aircraft then transported the detectors to LASL for analysis (27).

Project 18.1, Total Thermal Radiation and Atmospheric Transmission, was conducted by the Naval Research Laboratory to obtain information on the transmission of light and thermal radiation emitted by nuclear detonations of various yields. To measure the transmission of light, project personnel placed one photoelectric brightness meter at the Control Point and another in Area 2 of the NPG. In addition, they installed a transmissometer near the BJY and a receiver at the Control Point. Participants manually operated the instruments at the Control Point during the shot. To obtain data on thermal radiation emissions, personnel installed four thermopile recorder systems and operated them from the Control Point during the shot. They shut down equipment after the detonation to analyze recorded data (60).

Project 18.3, Color Temperatures, was conducted by the Naval Research Laboratory to measure the spectral characteristics of a nuclear fireball as a function of time. Measurements were taken with a high-speed spectrograph (39).

Project 18.4, High-resolution Spectroscopy, was conducted by the Naval Research Laboratory to supplement information obtained from spectroscopy measurements taken during previous nuclear weapons testing series, such as Operations GREENHOUSE and BUSTER-JANGLE. Project personnel installed spectrometers at the Control Poinnt, located 13 kilometers from ground zero (16).

Projects 19.1c and 19.1d, Shock-gauge Evaluations Tests, were conducted by Sandia Laboratory. Personnel from LASL and contractors assisted in calibrating and installing instruments. The project was intended to develop and test new instruments for measuring dynamic and static pressures, wind directions, sound

and wind speeds, and temperature rises resulting from a shock wave. Project personnel installed instruments at a station 940 meters from ground zero. Cables connected the instruments to equipment that recorded the information (26).

4.2.3 Air Force Special Weapons Center Activities

The Air Force Special Weapons Center provided personnel to staff the Air Operations Center, located at the Control Point. AFSWC also conducted cloud sampling and sample courier missions for the test groups and cloud tracking and aerial radiological surveys of the terrain for the Test Manager. In addition, Strategic Air Command personnel witnessed the detonation as part of an undesignated observer activity. Although the SAC observers were not part of AFSWC, they are discussed in this section because they were under the operational control of AFSWC while flying over the NPG. The following listing indicates the types and numbers of aircraft and the estimated numbers of personnel involved in missions at Shot GEORGE (1-3; 5; 36; 37; 52; 69):

TITLE	TYPE OF AIRCRAFT	NUMBER OF AIRCRAFT	NUMBER OF PERSONNEL
Sampling			
Sampler Control	B-29	1	9
Sampler	B-29	1	8
Sampler	T-33	4	8
Sampler	F-84	7	7
Sample Courier Service	B-25	3	15
	C-47	1	4
Cloud Tracking	B-25	1	5
	B-29	2	20
Aerial Surveys of Terrain	C-47	2	10
	L-20	1	2
Observer Activities	B-50	2	24

Cloud Sampling

One B-29, four T-33s, and seven F-84s collected particulate and gaseous samples of the Shot GEORGE cloud for Project 7.3, Radiochemical and Physical Analysis of Atomic Bomb Debris, and for Program 13, Radiochemistry Sampling. A B-29 sampler control aircraft, with an AFSWC aircrew and a LASL scientific advisor onboard, flew from Indian Springs AFB at 0404 hours and directed the operations of the sampler aircraft. The samplers flew at altitudes of 27,000 to 35,000 feet and made a total of 20 penetrations of the cloud. The following listing details the activities of each sampler (1-3; 36; 37; 52; 69):

AIRCRAFT TYPE AND TAIL NUMBER	TAKEOFF TIME	TOTAL TIME IN CLOUD (seconds)	TOTAL DOSIMETER READING (roentgens)	LANDING TIME
Sampler Control B-29 (285)	0404			1000
B-29 (386)	0352	NR*	0.750	0627
T-33 (951)	0622	NR	0.260	0744
T-33 (048)	0634	NR	1.400	0803
T-33 (913)	0629	120	0.380	0736
T-33 (920)	0407	53	6.000	0505
F-84 (791)	0725	180	0.100	0840
F-84 (834)	0639	NR	0.075	0800
F-84 (717)	0730	100	0.050	0843
F-84 (859)	0733	NR	0.100	0838
F-84 (781)	0506	NR	0.080	0532
F-84 (781)	0852	120	0.070	0958
F-84 (030)	0407	NR	0.400	0525

*NR indicates not reported.

After the detonation, the sampler control aircraft was delayed on takeoff because of hydraulic trouble. It was airborne by 0404 hours. One T-33 sampler aircraft (tail number 920) encountered a highly radioactive part of the cloud during its sampling pass. After reporting a radiation intensity of 140 R/h to the scientific advisor aboard the sampler control aircraft, the T-33 returned to Indian Springs AFB (36).

On completing their mission, the samplers returned to Indian Springs AFB and parked in the northeast corner of the parking area. Pilots then shut down the engines. The crews of the B-29s left the aircraft through the rear door between the stabilizer and the wing. The crews of the T-33s and F-84s disembarked by s[illegible]ping onto a boarding ladder attached to the side of the aircraft. The sample-removing team and radiological safety monitors used long-handled tools to remove the filter papers and place them in shielded containers. They used the same method to remove the bottles containing the gaseous samples. They then loaded the sample containers onto courier aircraft for delivery to laboratories for analysis (1-3; 36; 37; 52; 69).

Courier Missions

After the sampling missions had been completed, three B-25s and one C-47 aircraft left Indian Springs AFB on shot-day to transport samples and filter papers to various laboratories for analysis. The 4901st Support Wing (Atomic) conducted these missions (1-3; 36; 37; 52; 69).

At about 0700 hours, a B-25 flew from Indian Springs AFB to McClellan AFB with Project 7.3 samples. Soon after, a C-47 flew from Indian Springs AFB to LASL with Program 13 samples. At 0800 hours, a B-25 left Yucca Lake airstrip with Project 17.1 samples for LASL. At an unspecified time, a B-25 flew from Indian Springs AFB to the Army Chemical Center with Project 6.3 samples (1-3; 36; 37; 52; 69).

Cloud Tracking

Soon after the detonation, one B-25 and two B-29s from Indian Springs AFB flew cloud-tracking missions over and beyond the Nevada Proving Ground. The B-25 (tail number 099) took off at 0418 hours, tracked the cloud at heights ranging from 900 to 14,000 feet, and landed at 0905 hours. The B-29 (tail number unknown) took off at 0410 hours and landed at 1155 hours. The second B-29 (tail number 826) left at 0917 hours, tracked the cloud at heights ranging from 18,000 to 22,000 feet, and landed at 1300 hours. The C-47 (tail number unknown) left at 0650 hours and returned at 1255 hours. The flight profile of the C-47 is not known (1-3; 36; 37; 52; 69).

Aerial Surveys of Terrain

After the detonation, two C-47s and one L-20 aircraft, all based at Indian Springs AFB, conducted radiological surveys of the onsite and offsite terrain. One C-47 (tail number 386) left at 0630 hours, flew at 300 to 1,500 feet above the terrain, and returned at 1125 hours. A second C-47 aircraft (tail number 308) took off at 0650 hours, flew at heights of 1,000 to 10,000 feet, and landed at 1255 hours. The L-20 (tail number 467) took off at 0530 hours, conducted its survey at 100 to 500 feet above the terrain, and landed at 0805 hours (1-3; 36; 37; 52; 69).

Observer Activities

Observers from the Strategic Air Command participated in an orientation and indoctrination exercise in nuclear weapons effects. On shot-day, two B-50s, possibly from Carswell AFB, Texas, with SAC observers onboard entered the Nevada Proving Ground area between 0100 and 0300 hours. One B-50 aircraft remained in an orbiting pattern through shot-time to allow the observers to witness the detonation and subsequent cloud development. This aircraft left the shot area at 0400 hours to return to its base. The other B-50 conducted a weather

reconnaissance mission. It is not known when the B-50 weather reconnaissance aircraft returned to its home base (1-3; 5; 36; 37; 52; 69).

4.3 RADIATION PROTECTION AT SHOT GEORGE

The primary purpose of the TUMBLER-SNAPPER radiation protection procedures developed by Exercise Desert Rock IV, the test groups, and AFSWC was to minimize individual exposure to ionizing radiation, while still allowing participants to accomplish their missions (43).

4.3.1 Desert Rock Radiation Protection Activities

For the maneuver conducted at Shot GEORGE, responsibility for the radiological safety of personnel was delegated to the Army (51).

Orientation and Briefing

Participants at Shot GEORGE attended the final indoctrination course conducted from 28 May to 1 June by members of the Instructor Group. The instructors for this course were from AFSWP. The orientation covered personal protection procedures and medical effects, as well as basic characteristics of nuclear weapons (43; 51).

Dosimetry and Protective Equipment

The Desert Rock Signal Section issued film badges, and the Quartermaster Section issued protective masks to participants in the maneuver. At the indoctrination course, the instructors told the participants to place their film badges in their left breast pocket, with the numbers of the badge facing outward from the body. In addition, they instructed participants in the proper use of their masks, which were to be worn if evacuation of the

area was necessary. The AFSWP Radiological Safety Group processed all film badges (51).

Monitoring

After the passage of the blast wave, two monitoring teams from the Desert Rock Radiological Safety Group left Parking Areas O and N, shown in figure 4-3, to precede the advancing troops. Using AN/PDR-T1B meters, they marked the 0.5 R/h line. The teams followed the routes through the maneuver area shown in figure 4-3. One team monitored intensities in the equipment display area, and the other surveyed Parking Area P. The teams reported the intensities to the Control Point (51).

After the troop monitors had surveyed the maneuver area, troops and observers inspected the equipment displays. Monitors accompanied each advancing column to advise the officer in charge of radiation intensities. Troops were able to advance within 460 meters of ground zero before encountering the 0.5 R/h line, which was the forward limit for maneuver troops. They were able to view the entire equipment display area (51).

Decontamination

In Parking Area P, shown in figure 4-3, decontamination personnel brushed troops with brooms to remove contaminated dust. They then surveyed all personnel with AN/PDR-T1B meters. Individuals whose contamination levels had not been reduced to less than 0.01 R/h were directed to take showers at the decontamination station at Yucca Pass.

Decontamination personnel also monitored vehicles. They sent vehicles to the decontamination station if brushing could not reduce the level of contamination to less than 0.01 R/h (51).

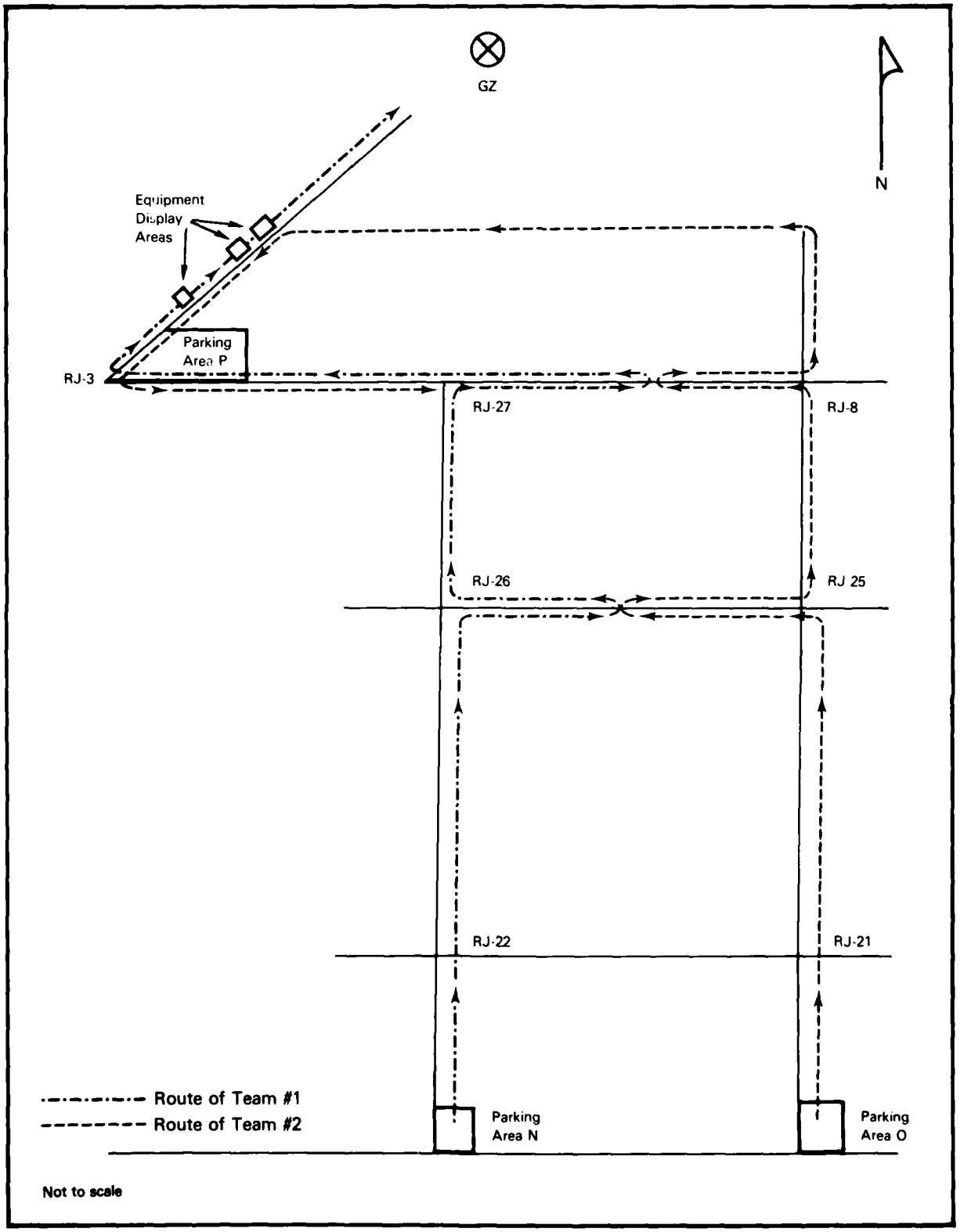


Figure 4-3: RECONSTRUCTED ROUTE OF DESERT ROCK SURVEY TEAMS, SHOT GEORGE

4.3.2 Joint AEC-DOD Radiation Protection Activities

Information concerning Shot GEORGE has been obtained from the radiological safety report prepared by AFSWP (43). This document includes logistical data on radiological safety equipment, onsite and offsite monitoring procedures, and isointensity contour maps.

Logistics and Materiel

During the period 1 to 4 June 1952, which covers the 1 June detonation of Shot GEORGE, the Logistics and Materiel Department issued film badges to about 300 DOD and AEC participants in 19 programs and 38 projects. The department also issued 460 sets of protective clothing and 250 radiation survey instruments (43).

Monitoring

Shot GEORGE was detonated in Area 3. The initial ground survey began at 0530 hours and continued until 0548 hours. Monitors could not complete the survey on shot-day because of radiation intensities in excess of 10.0 R/h to the north. Later surveys showed a considerable amount of fallout from GEORGE through Area 7, about five kilometers north of Area 3, and through the BUSTER-JANGLE area about ten kilometers north of Area 3. The Test Manager closed Area 7, which had been open since 11 May 1952.

From eight to 13 two-man mobile teams participated in off-site monitoring. About six hours before the detonation, they left the test area for their assigned locations. They found that fallout occurred mostly to the north. The maximum recorded intensity was 1.3 R/h, about 50 kilometers north of ground zero an hour after the detonation (43).

Two C-47s and an L-20 aircraft began aerial surveys of the terrain shortly after the detonation. The maximum intensity

encountered was 0.07 R/h, 500 feet above a location a few kilometers north of the NPG (43).

Plotting and Briefing

Ground monitoring teams provided survey data used in plotting radiation isointensity contours. The initial radiation isointensity map is shown in figure 4-4. The isointensity maps generated from resurveys of the area are shown in figure 4-5 (43). Labels of the maps in the source document do not always reflect the range of survey times given in the tables of intensity readings that accompany the maps.

Decontamination

Shot GEORGE produced more fallout than expected in the target area, resulting in "unusually extensive" decontamination activities (43).

Dosimetry Data

The AFSWP radiological safety report indicates that six AFSWP participants who were issued film badges during the period 1 to 4 June 1952 accumulated exposures between 3.0 and 10.0 roentgens (43).

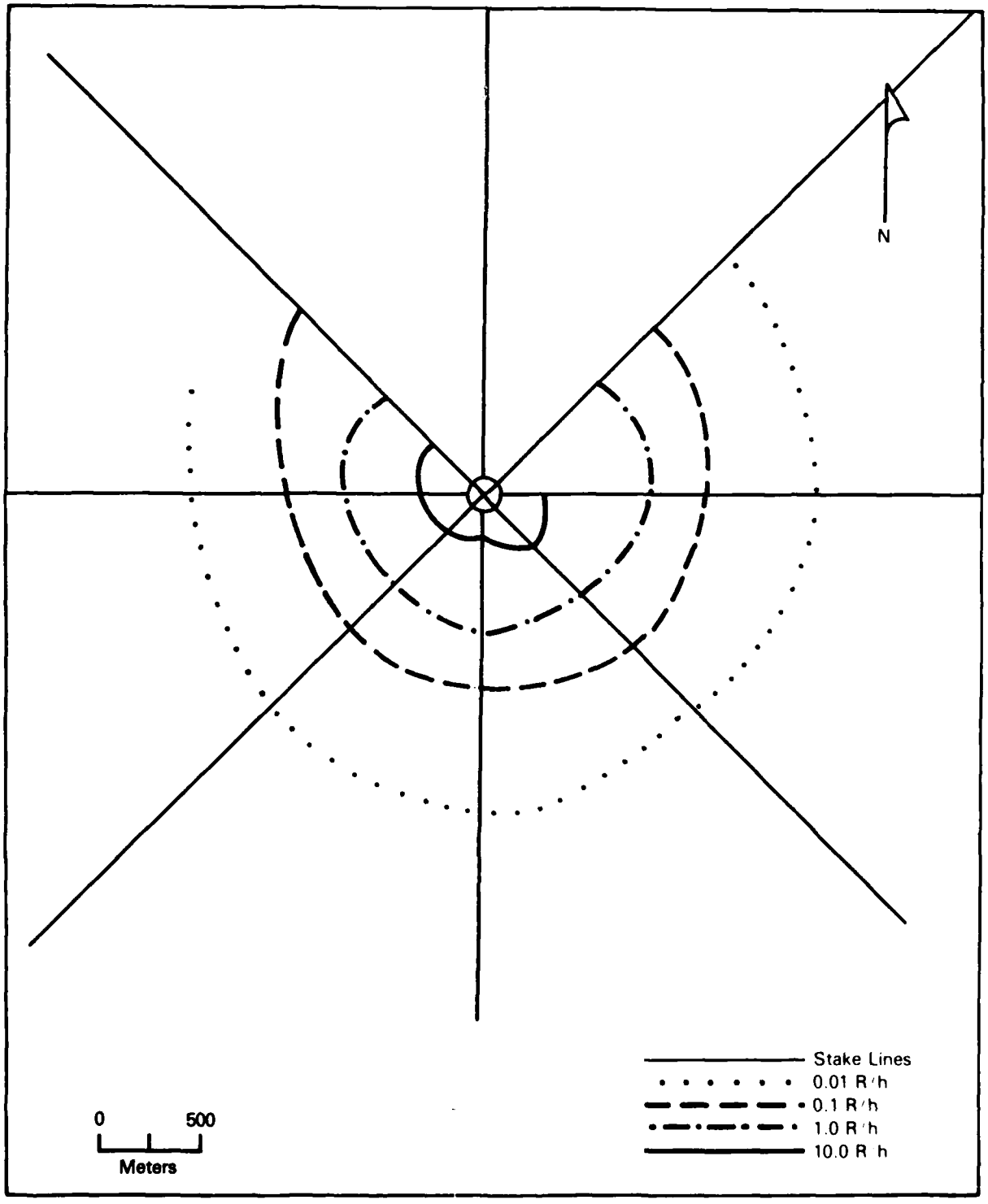
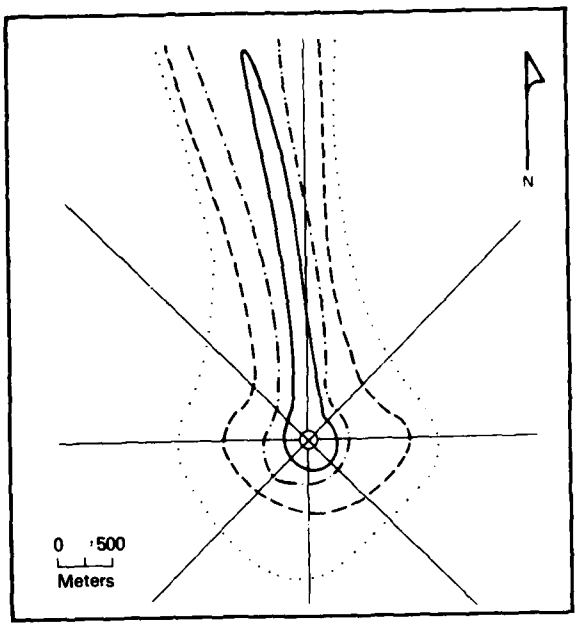
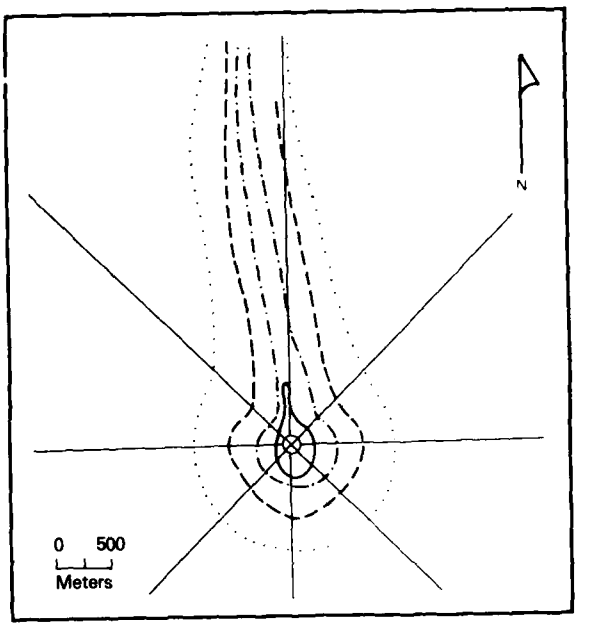


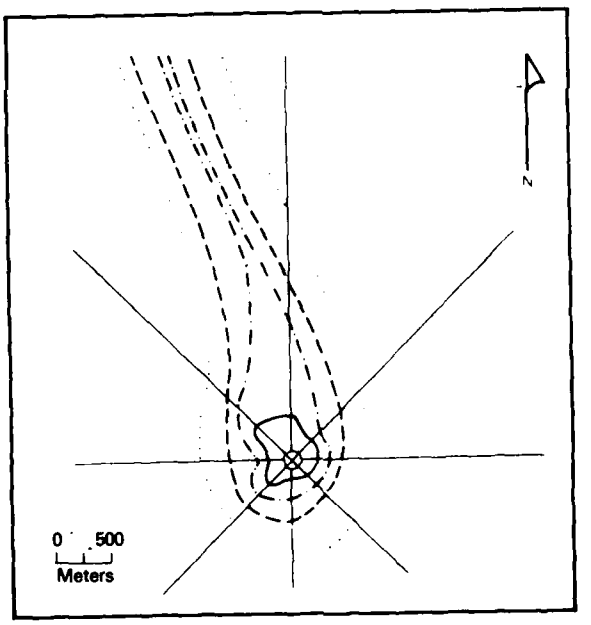
Figure 4-4: INITIAL RADIATION ISOINTENSITY MAP FOR SHOT GEORGE, 1 JUNE 1952, 0530 HOURS



2 JUNE 1952, 0530 HOURS



3 JUNE 1952, 0530 HOURS



4 JUNE 1952, 0530 HOURS

Stake Lines
0.01 R/h
0.1 R/h
1.0 R/h
10.0 R/h

Figure 4-5: SUBSEQUENT RADIATION ISOINTENSITY MAPS FOR SHOT GEORGE

SHOT HOW SYNOPSIS

AEC TEST SERIES:	TUMBLER-SNAPPER
DOD EXERCISE:	None
DATE/TIME:	5 June 1952, 0355 hours
YIELD:	14 kilotons
HEIGHT OF BURST:	300 feet (tower)

DOD Objective: To determine the military value of weapons for offensive and defensive deployment.

Weather: At shot-time, the surface winds were calm. Winds were 13 knots from the southeast at 10,000 feet, 15 knots from the south-southeast at 20,000 feet, and 25 knots from the south-southeast at 30,000 feet. The temperature was 18°C, the relative humidity was 45 percent, and the pressure was 863 millibars.

Radiation Data: The onsite fallout pattern extended north and northwest of ground zero. The initial radiological survey team did not monitor that area because no recovery operations were necessary there. In other directions, the survey team measured radiation intensities of 0.01 R/h as far as two kilometers from ground zero.

Participants: Armed Forces Special Weapons Project; Air Force Special Weapons Center; Atomic Energy Commission; Los Alamos Scientific Laboratory; contractors.

CHAPTER 5

SHOT HOW

Shot HOW was detonated with a yield of 14 kilotons at 0355 hours Pacific Standard Time on 5 June 1952. HOW, the last nuclear test of Operation TUMBLER-SNAPPER, was originally planned for 27 May but was rescheduled because of adverse weather. Part of the SNAPPER phase of Operation TUMBLER-SNAPPER, Shot HOW was a weapons development test. Developed by the Los Alamos Scientific Laboratory, the nuclear device was detonated on a 300-foot tower in Area 2 of Yucca Flat, UTM coordinates 784104 (67). Figure 5-1 shows the Shot HOW detonation.

The top of the cloud formed by Shot HOW reached an altitude of 41,800 feet. The cloud dispersed in several directions, the lower portion moving northwest and the upper portion moving northeast (1; 2; 30; 40; 67).

5.1 DEPARTMENT OF DEFENSE PARTICIPATION IN SCIENTIFIC AND SUPPORT ACTIVITIES AT SHOT HOW

The Desert Rock activities originally planned for Shot HOW had been conducted at Shot GEORGE several days earlier, but DOD personnel did take part in scientific and diagnostic experiments conducted by the Military Effects Test Group and the Weapons Development Test Group. Table 5-1 lists the test group projects and identifies the participating organizations. In addition to participating in test group experiments, the Air Force Special Weapons Center provided air support to the test groups and to the Test Manager.

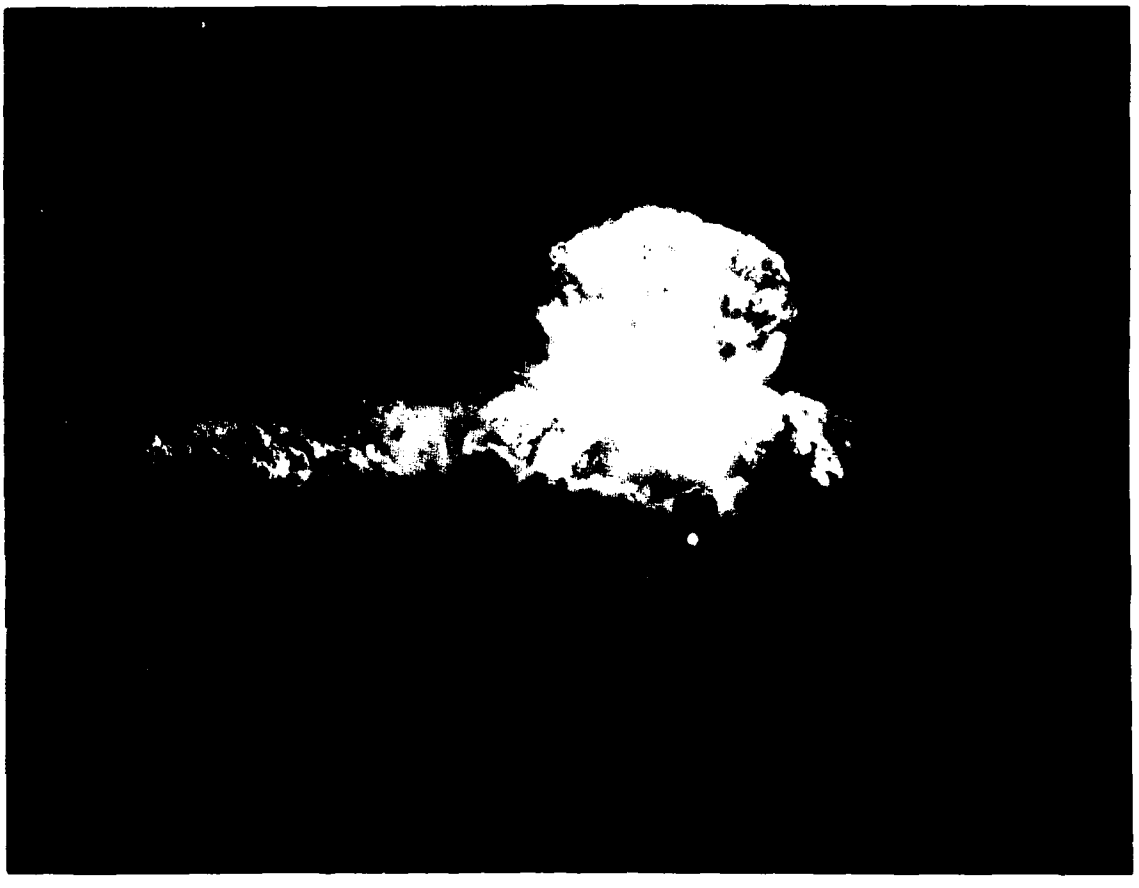


Figure 5-1: SHOT HOW, DETONATED AT 0355 HOURS ON 5 JUNE 1952

Table 5-1: TEST GROUP ACTIVITIES WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT HOW

Project/ Program	Title	Participants
Military Effects Test Group		
1.1	Measurement of Free Air Atomic Blast Pressures	Air Force Cambridge Research Center; Rome Air Development Center
2.1	Total Gamma Exposure versus Distance	Signal Corps Engineering Laboratories
2.2	Gamma Ray Energy Spectrum of Residual Contamination	Signal Corps Engineering Laboratories
2.3	Neutron Flux and Energy Measurements	Naval Research Laboratory
4.2	Biomedical Exposure Equipment	Naval Medical Research Institute
4.3	Biological Effectiveness of Neutron Radiation from Nuclear Weapons	Naval Radiological Defense Laboratory
4.4	Gamma Depth Dose Measurement in Unit Density Material	Naval Medical Research Institute
6.1	Evaluation of Military Radiac Equipment	Bureau of Ships; Signal Corps Engineering Laboratories
6.5	Decontamination of Aircraft	Wright Air Development Center; Naval Radiological Defense Laboratory
6.7	Evaluation of Air Monitoring Instruments	Army Chemical Center
7.1a	Electromagnetic Effects from Atomic Explosions	National Bureau of Standards; Air Force Cambridge Research Center; Air Weather Service; Geophysical Laboratory of the University of California at Los Angeles
7.1b	Long Range Light Measurements	EG&G; Headquarters, Air Force
7.2	Detection of Airborne Low-frequency Sound from Atomic Explosions	Headquarters, Air Force; Signal Corps Engineering Laboratories; National Bureau of Standards
7.3	Radiochemical and Physical Analysis of Atomic Bomb Debris	Headquarters, Air Force
7.4	Seismic Waves from A-Bombs Detonated over a Desert Valley	Air Force 1009th Special Weapons Squadron; Coast and Geodetic Survey

Table 5-1: TEST GROUP ACTIVITIES WITH DEPARTMENT OF DEFENSE PARTICIPATION, SHOT HOW (CONTINUED)

Project/ Program	Title	Participants
Military Effects Test Group (Continued)		
8.7	Thermal Radiation Measurements	Department of Engineering, University of California at Los Angeles
9.1	Technical and Training Photography	Naval Medical Research Institute; Air Force Lookout Mountain Laboratory; Wright Air Development Center; Army Pictorial Service Division; 4925th Test Group (Atomic); SAC 5th and 28th Reconnaissance Technical Squadrons; Signal Corps Engineering Laboratories
9.2	Air Weather Service Participation	Air Weather Service
9.4	Effects of Atomic Explosions on the Ionosphere	Signal Corps Engineering Laboratories; 9471st Technical Service Unit
Weapons Development Test Group		
10.1	Measurement of Alpha	Naval Research Laboratory
11.1	Measurement of Transit Time	Naval Research Laboratory
12.1	Technical Photography	EG&G
12.1c	Bhangmeter Mod II	EG&G
12.2a-d	High-speed Photography	EG&G; Los Alamos Scientific Laboratory
13	Radiochemistry Sampling Program	4925th Test Group (Atomic)
15.2	Gamma Radiation Exposure as a Function of Distance	Los Alamos Scientific Laboratory
15.3	Radiation Monitoring Measurements	Los Alamos Scientific Laboratory
17.1 *and* 17.2	External Neutron Measurements	Los Alamos Scientific Laboratory; AFSWC
18.1	Total Thermal Radiation and Atmospheric Transmission	Naval Research Laboratory
18.3	Color Temperatures	Naval Research Laboratory
18.4	High-resolution Spectroscopy	Naval Research Laboratory
19.1c-d	Shock-gauge Evaluations Tests	Sandia Laboratory
19.2a-b	Blast-wave Material Velocity Measurements	Los Alamos Scientific Laboratory; EG&G

5.1.1 Military Effects Test Group Projects

In conducting the Military Effects Test Group projects at Shot HOW, participants spent several weeks before the detonation placing and calibrating instruments. They usually completed these operations on the day before the detonation and then left the area. Figure 5-2 shows the instrument layout for the Military Effects Test Group projects at HOW (33).

The following project descriptions often discuss recovery operations as occurring after the announcement of recovery hour. The actual time of recovery hour is not known, although it probably was declared shortly after the completion of the initial radiological survey at 0700 hours.

Project 1.1, Measurement of Free Air Atomic Blast Pressures, was conducted by the Air Force Cambridge Research Center, with support from the Rome Air Development Center. The objective was to measure the pressures produced by a nuclear detonation over a wide range of altitudes and distances (46; 63; 73).

At 2000 hours the evening before the detonation, three project participants checked instruments for tracking the position of airdropped canisters east and south of the shot area. They remained in the area until three hours before the detonation and then proceeded to a telemetry station 730 meters north of the Control Point, where they remained through shot-time.

At 2100 hours, four men traveled to a station 800 meters northwest of the telemetry station, where they remained during the shot. Also at 2100 hours, two men spent one hour adjusting equipment at an underground canister-tracking station 1,830 meters southeast of ground zero. The following activities began at 2300 hours (46; 63):

- Two men traveled to another of the underground canister-tracking stations, about three

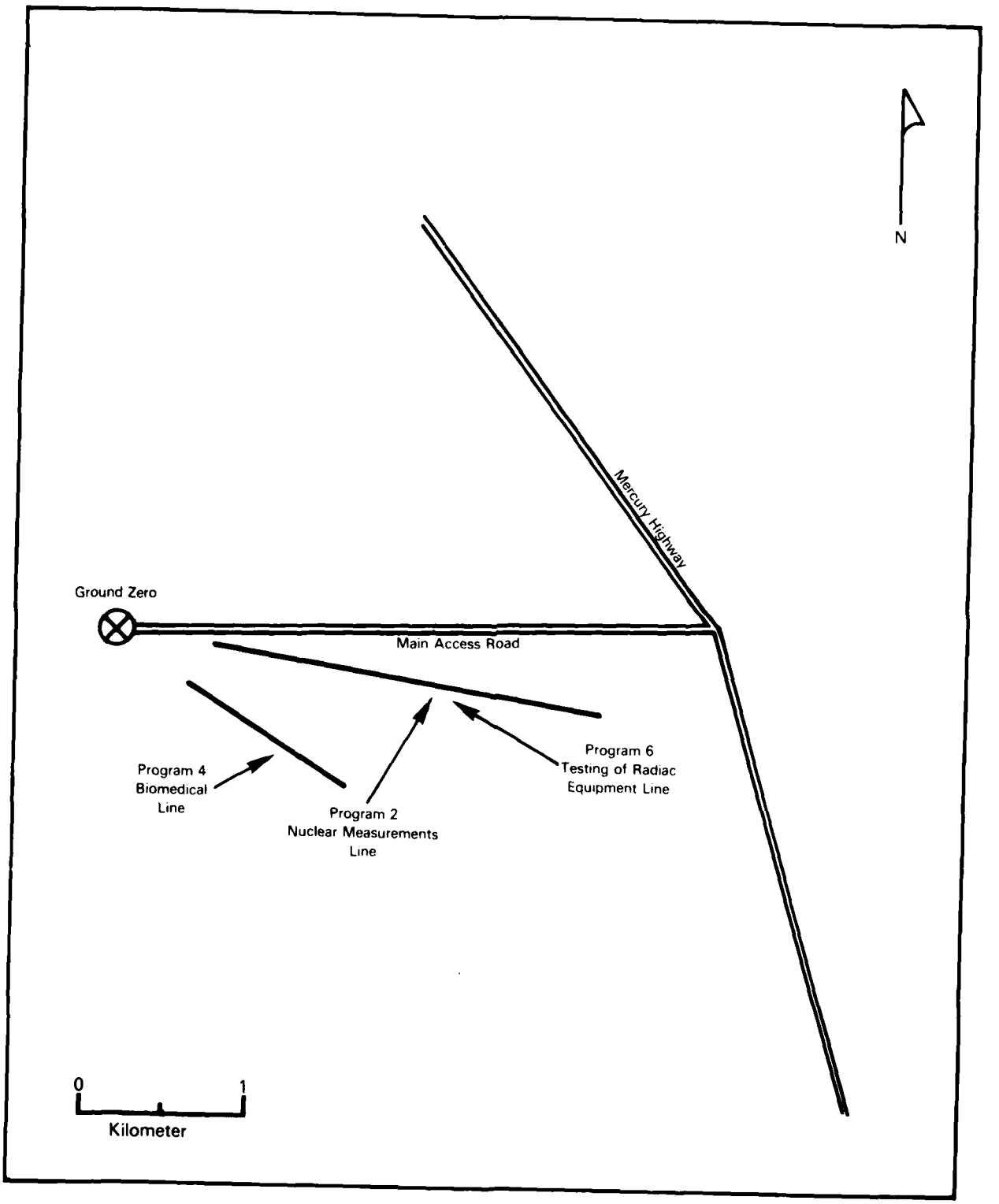


Figure 5-2: HOW GROUND ZERO AREA AND AFSWP MILITARY EFFECTS TEST GROUP INSTRUMENT LAYOUTS

kilometers southeast of ground zero, and spent two hours checking instruments.

- Two individuals spent three hours checking the radar homing beacon 460 meters from ground zero.
- Ten participants traveled to a telemetry station 730 meters north of the Control Point. After remaining at the station through shot-time, they returned to the Control Point.
- Fourteen personnel traveled to the radar station about 24 kilometers from ground zero, where they remained until 15 minutes after the detonation.
- Two participants went to a canister-tracking beacon 16 kilometers southeast of ground zero to check instruments. Three hours before the detonation, they proceeded to the manned canister-tracking station 14 kilometers south-southwest of ground zero.
- Four men traveled to the manned tracking station 22 kilometers southeast of ground zero to operate the station until an hour after shot-time.
- Three personnel traveled to the manned tracking station 14 kilometers south-southwest of ground zero, where they remained through shot-time.

Several hours before the detonation, two B-29 aircraft from the 6531st Flight Test Squadron, Rome Air Development Center, began calibration runs over ground zero. The aircraft dropped the instrumented canisters about one minute before the detonation. The following list details the activities of these two aircraft:

SERIAL NUMPER	TAKEOFF TIME	ARRIVED SHOT AREA	DEPARTED SHOT AREA	LANDING TIME
1863	2150	0128	0401	0510
1742	2155	0045	0358	0510

The aircraft staged from Kirtland AFB, New Mexico (46; 63; 73).

At 0900 hours on the day after the detonation, four persons began recovering instruments from the underground instrument tracking station 1,830 meters east of ground zero. This procedure took about three hours. Also at 0900 hours, ten personnel located and recovered the canisters (46; 63; 73).

Project 2.1, Total Gamma Exposure versus Distance, was conducted by the Signal Corps Engineering Laboratories to measure gamma radiation exposure as a function of distance. Shortly before the detonation, project personnel placed film packets in instrument shelters at 90-meter intervals along a radial line extending 1,100 to 2,740 meters from the point of detonation. When the Test Manager opened the area for recovery operations, four project personnel drove a truck into the shot area and spent about two hours retrieving film located nearly 2,740 meters from ground zero (57; 63).

Project 2.2, Gamma Ray Energy Spectrum of Residual Contamination, was conducted by the Signal Corps Engineering Laboratories. The objective was to determine the spectral distribution of gamma radiation in the test area following a nuclear detonation. The project was also intended to evaluate radiac instruments (77).

Before the shot, project personnel modified and calibrated five AN/PDR-T1B radiac instruments. At recovery hour, project participants carried the instruments into the shot area and set them up in a line on wooden tripods facing ground zero.

Project personnel took the first radiac instrument reading 1,290 meters from ground zero, approximately four hours after the detonation. Additional readings were taken during the two days following the shot at distances of 650 to 1,770 meters from ground zero (63; 77).

Project 2.3, Neutron Flux and Energy Measurements, was conducted by the Naval Research Laboratory. The objectives were to measure neutron flux for the interpretation of biological studies and to study neutron dosimetry techniques. Project personnel placed gold and sulphur neutron flux detectors at stations along a radial line at distances of 200 to 1,830 meters from the shot-tower (44).

Two men who entered the shot area to retrieve the neutron detectors from the Project 4.3 line 200 to 1,830 meters east of ground zero also recovered the neutron flux detectors. In addition, two men entered the shot area with LASL Project 17.1 personnel and spent about three hours recovering records.

Project 4.2, Biomedical Exposure Equipment, was conducted by the Naval Medical Research Institute to measure nuclear blast effects on animals. Wood models of dogs that contained accelerometers were put in open mesh cages on blast barriers to measure and record various blast and pressure phenomena. The wooden blast barriers were 550, 640, and 790 meters from ground zero. Two movie cameras were placed at one side of each wooden barrier to record the movement of the cages when the blast wave arrived. After recovery hour was declared, three personnel recovered the film. The task took about one hour (34; 63).

Project 4.3, Biological Effectiveness of Neutron Radiation from Nuclear Weapons, was conducted by the Naval Radiological Defense Laboratory. The objective was to study the biological effects of neutron radiation on mice (21).

On the day before the detonation, eight participants placed approximately 30 mice at each of 28 field stations. They spent about one hour in this assignment and then left the shot area. The stations, which were shielded with lead, bismuth, or aluminum, were approximately 200 to 1,830 meters from ground zero.

After the area was opened for recovery operations, 19 project participants spent about 30 minutes retrieving mice and neutron detectors at stations 870 meters from ground zero. Laboratory personnel performed a pathological analysis to determine the effects of neutron radiation on the mice (21; 63).

Project 4.4, Gamma Depth Dose Measurement in Unit Density Material, was performed by the Naval Medical Research Institute. The objective was to improve the techniques used to evaluate the biological effects of radiation on the human body. Project personnel used lucite spheres approximating human tissue in density. Ionization chambers or other radiation detecting instruments were installed in the spheres, shown in figure 5-3, to measure the initial and residual gamma doses at various depths. Before the detonation, participants placed five spheres of various thicknesses on A-frames approximately 1,370 to 1,700 meters southeast of ground zero. After the declaration of recovery hour, seven project personnel in a weapons carrier and a pickup truck spent about one hour retrieving the spheres (22; 63).

Project 6.1, Evaluation of Military Radiac Equipment, was conducted by the Bureau of Ships and the Signal Corps Engineering Laboratories to evaluate radiac survey equipment. Before the shot, project personnel placed dosimeters at ranges of 910 to 2,750 meters from ground zero. At recovery hour, six project personnel began recovering the dosimeters, an activity taking three hours. In addition, Project 6.1 personnel furnished standard and experimental radiation survey instruments and dosimeters to other projects so that the instruments could be evaluated (63; 72).

Project 6.5, Decontamination of Aircraft, was conducted by the Wright Air Development Center and the Naval Radiological

Figure 5-3: PROJECT 4.4 PERSONNEL PREPARE LUCITE SPHERES USED TO MEASURE GAMMA RAY DEPTH DOSE

Defense Laboratory. The objective was to study methods of reducing the radiation exposures of maintenance and flight crews.

To study adhesion of contamination to differently treated surfaces, project personnel treated various parts of a T-33A and an F-84G aircraft with acid, polish, oil, or some combination of the three. They surveyed the aircraft before and after decontamination with the USNRDL Mark V Model I beta contamination monitor and the AN/PDR-T1B survey meter. The highest level of contamination, 5.0 R/h, was measured with the AN/PDR-T1B meter on the oiled surfaces (36; 76).

Project 6.7, Evaluation of Air Monitoring Instruments, was conducted by the Army Chemical Center to determine the adequacy of a Chemical Corps air sampler for radiological air monitoring. Samplers were placed at four stations located 9.2 kilometers north, 9.2 kilometers north-northeast, 10.5 kilometers north-northeast, and 10.5 kilometers northeast of ground zero. Because fallout from Shot HOW was to the northwest, there was no measurable radiation intensity at the first two stations when instruments were recovered eight hours after the shot. At the other two stations, radiation levels were 0.18 and 0.25 R/h, respectively, because of residual radiation from previous shots (45).

Project 7.1a, Electromagnetic Effects from Atomic Explosions, was conducted by the National Bureau of Standards, Air Force Cambridge Research Center, Air Weather Service, and the Geophysical Laboratory of the University of California at Los Angeles. The project was designed to study at onsite and offsite stations the electromagnetic pulses produced by a nuclear detonation. Data were evaluated as a means of determining the location of distant nuclear detonations. The onsite stations were at Frenchman and Yucca Flats, and the offsite stations in Colorado, Florida, Georgia, Massachusetts, New Mexico, Virginia, Bermuda, Germany, and Puerto Rico (64).

At 2400 hours on the night before the shot, three men adjusted equipment at stations ten and 14 kilometers from ground zero. It is not known which of the stations was at Frenchman and which at Yucca Flats. Three hours before the detonation, project personnel went to another Yucca Lake station, 21 kilometers from ground zero, and remained there through shot-time. Two hours after the detonation, project participants returned to Camp Mercury. At 0900 hours on the day after the detonation, two men spent three hours recovering records from these stations (63; 64).

Project 7.1b, Long Range Light Measurements, was conducted entirely offsite by EG&G and Headquarters, Air Force. The objective was to gain information on the long-range detection of light produced by a nuclear detonation. EG&G and the Air Force established light-detecting stations in Arizona, Idaho, Texas, and Washington. An estimated two EG&G employees and ten Air Force personnel from the Sacramento Air Materiel Area, McClellan AFB, operated each station from about six hours before to one hour after the detonation (35).

Project 7.2, Detection of Airborne Low-frequency Sound from Atomic Explosions, was conducted by Headquarters, Air Force, with assistance from the Signal Corps Engineering Laboratories and the National Bureau of Standards. The objective was to determine the accuracy of long-range acoustic detection methods. The Signal Corps Engineering Laboratories operated stations in Alaska, Hawaii, Kentucky, New Jersey, Texas, and Washington. The National Bureau of Standards operated a station in Washington, D.C. (65).

Project 7.3, Radiochemical and Physical Analysis of Atomic Bomb Debris, was conducted by Headquarters, Air Force. The project, which involved analysis of particulate and gaseous samples from the Shot HOW cloud, was conducted in conjunction with Program 13, Radiochemistry Sampling. Cloud sampling,

performed by the 4925th Test Group (Atomic) of Kirtland AFB, is discussed in section 5.1.3, on AFSWC participation at HOW (71).

Project 7.4, Seismic Waves from A-Bombs Detonated over a Desert Valley, was conducted by the Air Force 1009th Special Weapons Squadron and the Coast and Geodetic Survey. The objective was to determine the seismic properties of the geological structure of the test area. Five unmanned seismic stations functioned during shot-time. At 0900 hours on the day after the detonation, two men traveled to stations seven kilometers northwest and five kilometers northeast of ground zero and began recovering records, a process that took about three hours. They retrieved instruments and other data several days after the detonation (20; 63).

Project 8.7, Thermal Radiation Measurements, was performed by the UCLA Department of Engineering, under contract to the Air Research and Development Command. The purpose was to train employees of the UCLA Department of Engineering in the use of thermal radiation measuring instruments that were being devised for Operation IVY. Another objective was to collect data on the thermal radiation emitted from a nuclear test. Project personnel at Station 400, 23 kilometers from ground zero and near the Control Point at Yucca Pass, recorded data with an 18-channel oscillograph, among other instruments (63; 70).

Project 9.1, Technical and Training Photography, was conducted by personnel from the following agencies (9; 63):

- Air Force Lookout Mountain Laboratory
- Army Pictorial Service Division
- Naval Medical Research Institute
- Signal Corps Engineering Laboratories
- SAC 5th Reconnaissance Technical Squadron
- SAC 28th Reconnaissance Technical Squadron
- Wright Air Development Center
- 4925th Test Group (Atomic).

Personnel from these agencies photographed Shot HOW from the ground and the air. Lookout Mountain Laboratory personnel in a C-47 aircraft conducted the aerial photography mission. The C-47, which left Indian Springs AFB at about 0320 hours, was at an altitude of 10,000 feet approximately 11 kilometers south of ground zero at shot-time. Participants photographed the detonation and the resulting cloud formation and then returned to Indian Springs AFB, landing at 0430 hours (36; 63). Project 9.1 personnel also took photographs and motion pictures of various Military Effects Test Group projects.

Project 9.2, Air Weather Service Participation, involved Air Force personnel who compiled data from various weather stations at the NPG and offsite, prepared weather maps, and briefed NPG officials on current and predicted weather conditions. Project participants were from the 6th Weather Squadron (Mobile) of the 2059th Air Weather Wing, Tinker AFB, Oklahoma. These personnel were deployed as follows (54):

- Eight forecasters, 13 weather observers, and two equipment operators at the Control Point Weather Station near Yucca Pass
- Twelve airmen from the Rawinsonde Weather Observation Section at the Control Point and 11 airmen at a station in Tonopah, Nevada
- Three airmen from the Pibal Weather Observation Section at Beatty, Caliente, Crystal Springs, Currant, and Warm Springs, Nevada, and St. George, Utah.

Project 9.4, Effects of Atomic Explosions on the Ionosphere, was conducted by the Signal Corps Engineering Laboratories. They were assisted by personnel of the 9471st Technical Service Unit. The objective was to obtain data on the effects of a nuclear detonation on ionospheric radiowave propagation. Project personnel worked at transmitter and receiver stations. The only onsite facility was a transmitter at Station 9.4, 910 meters north of the Control Point. Two other transmitters were at

Mather AFB, Sacramento, California. The radio receiver stations were at the Navaho Ordnance Depot, Flagstaff, Arizona; White Sands Proving Ground, New Mexico; and Fort Sill, Oklahoma.

The day before the shot, personnel practiced operating the transmitters and receivers. On shot-day, they operated instruments from one hour before to one hour after the detonation. Information obtained at the project stations was sent for analysis to the Signal Corps Engineering Laboratories (28).

5.1.2 Department of Defense Participation in Weapons Development Test Group Projects

Although most of the Weapons Development Test Group activities were performed by agencies under contract to the Atomic Energy Commission, some of the projects were conducted by DOD agencies. For example, the Naval Research Laboratory performed all of the experiments for Program 18, Thermal Measurements. In addition, a few DOD personnel were assigned to LASL or to the Weapons Development Test Group to assist in the projects listed in table 5-1.

Project 10.1, Measurement of Alpha, and Project 11.1, Measurement of Transit Time, were conducted by the Naval Research Laboratory (55).

Project 12.1, Technical Photography, was conducted by personnel from EG&G, with assistance from Navy personnel. They provided technical photography support, including dust studies, preshock turbulence studies, light absorption and mirage studies, fireball growth measurement, thermal effects studies, and other coverage required by the Weapons Development Test Group.

Two days before the shot, project personnel prepared the film at the Control Point Building. The afternoon before Shot

HOW, project personnel loaded film into remote-controlled cameras located at various stations in the ground zero area. After the detonation, EG&G personnel recovered the exposed film and processed some of it in the mobile unit set up in the Control Point area. The remaining film was flown to laboratories of Consolidated Film Industries in Hollywood, California, or in the city of Fort Lee, New Jersey, for processing (42).

Project 12.1c, Bhangmeter Mod II, was conducted by EG&G to evaluate and test a new bhangmeter. Project personnel installed these instruments for measuring the yield of a detonation at the Control Point. Bhangmeter readings recorded at shot-time were analyzed after the shot (41).

Project 12.2a-d, High-speed Photography, was conducted by LASL and EG&G. The objectives were to study early fireball growth and obtain measurements correlating shock arrival time with the appearance of the fireball. At Shot HOW, project participants mounted cameras in a trailer 3,200 meters from the shot-tower and, after the detonation, retrieved the film for analysis (38).

Program 13, Radiochemistry Sampling, involved cloud sampling conducted by personnel from the 4925th Test Group (Atomic). The sampling missions are discussed in section 5.1.3, on AFSWC activities (36).

Project 15.2, Gamma Radiation Exposure as a Function of Distance, was conducted by personnel from LASL. The objective was to measure gamma radiation exposure at various distances from the detonation. Project personnel placed gamma-detecting instruments in the ground at distances of 1,370 to 3,480 meters from ground zero. At recovery hour, four men in a vehicle entered the shot area to recover the instruments. They were scheduled to work in the area for 30 minutes (75).

Project 15.3, Radiation Monitoring Measurements, was conducted by personnel from LASL. The objectives were to monitor gamma radiation levels from the radioactive fallout after a nuclear detonation and to test several prototype radiation monitoring instruments for use at Operation IVY. The information on radiation levels was also used by recovery parties. Project personnel installed recording equipment in a station located about 460 meters east of ground zero. The recording equipment was set up to telemeter information on gamma radiation levels to the Control Point (59).

Projects 17.1 and 17.2, External Neutron Measurements, were conducted by personnel from LASL. The objective of these projects was to use threshold detectors to measure external neutron flux as a function of distance. LASL also provided some threshold detectors to the Naval Radiological Defense Laboratory and to the Naval Research Laboratory.

Project personnel attached some threshold detectors to horizontal steel bars about four feet above the ground along a radial line 370 to 1,470 meters from the shot-tower. Other detectors were fastened to a steel cable. Project participants also installed an underground shelter containing oscilloscopes set to run automatically at shot-time. After the detonation, project personnel retrieved the steel cable by using a tractor to drag it out of the shot area. Other project participants recovered the records from the underground shelter and retrieved the steel bars with the threshold detectors. At Yucca Lake, the threshold detectors were removed from the bars and the cable. AFSWC courier aircraft then transported the detectors to LASL for analysis (27).

Project 18.1, Total Thermal Radiation and Atmospheric Transmission, was conducted by the Naval Research Laboratory to study the transmission of light and thermal radiation emitted by

nuclear detonations of various yields. To measure the transmission of light, project personnel placed one photoelectric brightness meter at the Control Point and another in Area 2 of the NPG. In addition, they installed a transmissometer near the BJY and a receiver at the Control Point. Participants manually operated the instruments at the Control Point during the shot. To obtain data on thermal radiation emissions, personnel installed four thermopile recorder systems and operated them from the Control Point during the shot. They shut down equipment after the detonation to analyze recorded data (60).

Project 18.3, Color Temperatures, was conducted by the Naval Research Laboratory to measure the spectral characteristics of a nuclear fireball as a function of time. Measurements were taken with a high-speed spectrograph (39).

Project 18.4, High-resolution Spectroscopy, was conducted by the Naval Research Laboratory to supplement information obtained from spectroscopy measurements taken during previous nuclear weapons testing series, such as Operations GREENHOUSE and BUSTER-JANGLE. Project personnel installed a spectrograph at the Control Point, about 24 kilometers from ground zero (16).

Projects 19.1c and 19.1d, Shock-gauge Evaluations Tests, were conducted by Sandia Laboratory. Personnel from LASL and contractors assisted in calibrating and installing instruments. The project was intended to develop and test new instruments for measuring dynamic and static pressures, wind directions, sound and wind speeds, and temperature rises resulting from a shock wave. Personnel installed instruments at a station 945 meters from ground zero. Cables connected the instruments to equipment that recorded the information on shock wave phenomena (26).

Projects 19.2a and 19.2b, Blast-wave Material Velocity Measurements, were conducted by LASL. An officer and six men

from the Antiaircraft Artillery and Guided Missile Center, Fort Bliss, Texas, installed and maintained a 90-millimeter battery. EG&G provided photography services. The objective was to photograph peak overpressure phenomena associated with a nuclear burst. Smoke canisters were fired into the air from 90-millimeter guns immediately before the burst so that air disturbances would be visible.

Project personnel set up four 90-millimeter gun stations northeast of ground zero. These guns were fired by an electronic timing device. Project personnel entered the area before the shot to load smoke canisters into the guns. Other participants placed film in the automatically operated camera stations. EG&G personnel retrieved the film from these stations after the detonation (68).

5.1.3 Air Force Special Weapons Center Activities

The Air Force Special Weapons Center provided personnel to staff the Air Operations Center, located at the Control Point. AFSWC also conducted cloud sampling and sample courier missions for the test groups and cloud tracking and aerial radiological surveys for the Test Manager. In addition, Strategic Air Command personnel witnessed the detonation. Although the SAC observers were not part of AFSWC, they are discussed in this section because they were under the operational control of AFSWC while over the NPG (1-3; 5; 36; 37; 52; 69).

The following listing indicates the types and numbers of aircraft and the estimated numbers of personnel involved in air missions at Shot HOW:

TITLE	TYPE OF AIRCRAFT	NUMBER OF AIRCRAFT	NUMBER OF PERSONNEL
Sampling			
Sampler Control	B-29	1	9
Sampler	B-29	1	8
Sampler	T-33	4	8
Sampler	F-84	6	6
Sample Courier Service	B-25	3	15
	C-47	1	4
Cloud Tracking	B-25	1	5
	B-29	1	10
Aerial Surveys of Terrain	C-47	2	10
	L-20	2	4
Observer Activities	B-36	1	16

Cloud Sampling

One B-29, four T-33s, and six F-84s collected particulate and gaseous samples of the Shot HOW cloud for Project 7.3, Radiochemical and Physical Analysis of Atomic Bomb Debris, and for Program 13, Radiochemistry Sampling. A B-29 sampler control aircraft, with an AFSWC aircrew and a LASL scientific advisor onboard, flew from Indian Springs AFB at 0346 hours and was in position to direct sampling activities at 0410. The sampler control aircraft, however, encountered difficulties finding the Shot HOW cloud and vectoring the sampling aircraft to the cloud. The cloud rose quickly to a height of 41,800 feet and then began to disperse. The lower portion of the cloud, 17,000 to 20,000 feet, moved rapidly to the northwest, and the upper part moved to the northeast. The velocity of the leading edge of this cloud was about 50 knots, causing maximum dispersion at the most important sampling levels. The sampler aircraft were vectored to the lower cloud where most of the air sampling took place. The samplers flew at altitudes of 17,000 to 36,000 feet and made a

total of 22 penetrations of the cloud. The listing below details the activities of each sampler (1-3; 36; 37; 52; 69).

AIRCRAFT TYPE AND TAIL NUMBER	TAKEOFF TIME	TOTAL TIME IN CLOUD (seconds)	TOTAL DOSIMETER READING (roentgens)	LANDING TIME
Sampler Control B-29 (285)	0346			0916
B-29 (386)	0346	NR*	0.375	0836
T-33 (951)	0431	NR	0.200	0519
T-33 (048)	0631	NR	0.200	NR
T-33 (913)	0640	NR	0.000	NR
T-33 (920)	0627	NR	0.000	0743
F-84 (859)	0402	180	0.075	NR
F-84 (030)	0510	NR	0.040	0621
F-84 (791)	0703	180	0.025	NR
F-84 (834)	0642	0	0.000	NR
F-84 (717)	0706	240	0.015	NR
F-84 (NR)	0714	NR	0.020	NR

*NR indicates not reported.

Upon completion of their missions, the samplers returned to Indian Springs AFB and parked in the northeast corner of the parking area. Pilots then shut down the engines and opened the aircraft canopies. The crews of the B-29s left the aircraft through the rear door between the stabilizer and the wing. The crews of the T-33s and F-84s disembarked by stepping onto a boarding ladder attached to the side of the aircraft. The sample-removing team and radiological safety monitors used long-handled tools to remove the filter papers and place them in shielded containers. They used the same method to remove the bottles containing the gaseous samples. They then loaded the sample containers onto courier aircraft for delivery to AEC laboratories for analysis (1-3; 36; 37; 52; 69).

Courier Missions

After the sampling missions had been completed, three B-25 and one C-47 aircraft left Indian Springs AFB and Yucca Lake airstrip on shot-day to transport samples and filter papers to various laboratories for analysis. The 4901st Support Wing (Atomic) conducted these courier missions.

At about 0655 hours, a B-25 flew from Indian Springs AFB to McClellan AFB with Project 7.3 samples. Soon after, a C-47 flew from Indian Springs AFB to LASL with Program 13 samples. At 0745 hours, a B-25 left Yucca Lake airstrip with Project 17.1 samples for LASL. At 0855 hours, a B-25 flew from Indian Springs to the Army Chemical Center with Project 6.3 samples and to Bolling AFB with Project 2.3 samples (1-3; 36; 37; 52; 69).

Cloud Tracking

After the detonation, one B-25 and one B-29 from Indian Springs AFB flew cloud-tracking missions over and beyond the Nevada Proving Ground. The B-25 (tail number 099) took off at 0413 hours, tracked the cloud at altitudes of 9,000 to 14,000 feet, and returned at 0847 hours. The B-29 (tail number 826) took off at 0410 hours, tracked the cloud at altitudes of 18,000 to 22,000 feet, and landed at 1000 hours (1-3; 36; 37; 52; 69).

Aerial Surveys of Terrain

After the detonation, two C-47 and two L-20 aircraft, all based at Indian Springs AFB, conducted radiological surveys of the onsite and offsite terrain. One C-47 (tail number 308) left at 0555 hours, flew its mission at 500 to 1,000 feet above the terrain, and returned at 1139 hours. The other C-47 (tail number unidentified) took off at 0605 hours, conducted its survey at 1,700 feet and higher, and landed at 1131 hours. The L-20 aircraft (tail number 467) flew two missions about 100 feet above the terrain. For the first mission, the aircraft took off at

0925 hours to perform a special radiological safety mission. It returned to Indian Springs at 1155 hours, and then proceeded to the Yucca Lake airstrip. The aircraft then returned to Indian Springs, arriving at 1238 hours (1-3; 36; 37; 52; 69). The activities of the second L-20 are not known.

Observers

The crew of one SAC aircraft, a B-36 possibly from Carswell AFB, Texas, witnessed the HOW detonation. The B-36 entered the area over the NPG at 0338 hours and left the area at 0408 hours (1-3; 5; 36; 37; 52; 69).

5.2 RADIATION PROTECTION AT SHOT HOW

The primary purpose of the radiation protection procedures developed by the test groups and AFSWC for Operation TUMBLER-SNAPPER was to keep individual exposures to ionizing radiation to a minimum, while still allowing participants to accomplish their missions.

Logistics and Materiel

From 5 June to 9 June 1952, which covers the 5 June detonation of Shot HOW, the Logistics and Materiel Department issued 300 sets of protective clothing and 250 radiation survey meters. The department also issued film badges (43).

Monitoring

The initial ground survey team began recording radiation intensities at 0545 hours. The survey was completed along all but the north stake line by 0700 hours. Measurements were made along the north stake line between 0915 and 0940 hours. Winds resulted in a large amount of fallout northwest of the shot area, but no effort was made to complete the survey in that direction since early recovery operations were not necessary there (43).

Offsite ground monitoring teams and personnel who were to operate fixed sampling stations left for their assigned locations the day before the shot. The maximum intensity encountered by these offsite monitors was 0.045 R/h, about six hours after the detonation, between Tonopah and Warm Springs, Nevada, on U.S. Route 6 (about 110 kilometers northwest of ground zero). For about ten days after the detonation, offsite personnel rechecked all areas surrounding the NPG where any readings greater than 0.02 R/h had been noted. In addition, all water holes and potable water supplies in these areas were sampled. None of tne water samples showed detectable amounts of radioactivity.

Two C-47 and one L-20 aircraft conducted radiological surveys of the onsite and offsite terrain. The maximum intensity encountered by these aircraft was 0.011 R/h, 400 feet above a location about 50 kilometers northwest of ground zero, four hours after the detonation (43).

Plotting and Briefing

Monitors working in the field with recovery parties provided survey data for the radiation isointensity plots. Plotting and Briefing personnel consolidated these data to make the initial radiation isointensity map, a copy of which is shown in figure 5-4. Copies of the isointensity maps generated from resurveys on subsequent days are shown in figure 5-5 (43). The labels of the maps in the source document do not always reflect the range of survey times given in the tables of intensity readings that accompany the maps.

Dosimetry Data

The AFSWP radiological safety report indicates that no individual who was issued a film badge during the period 5 to 9 June 1952 received an exposure in excess of 3.0 roentgens (43).

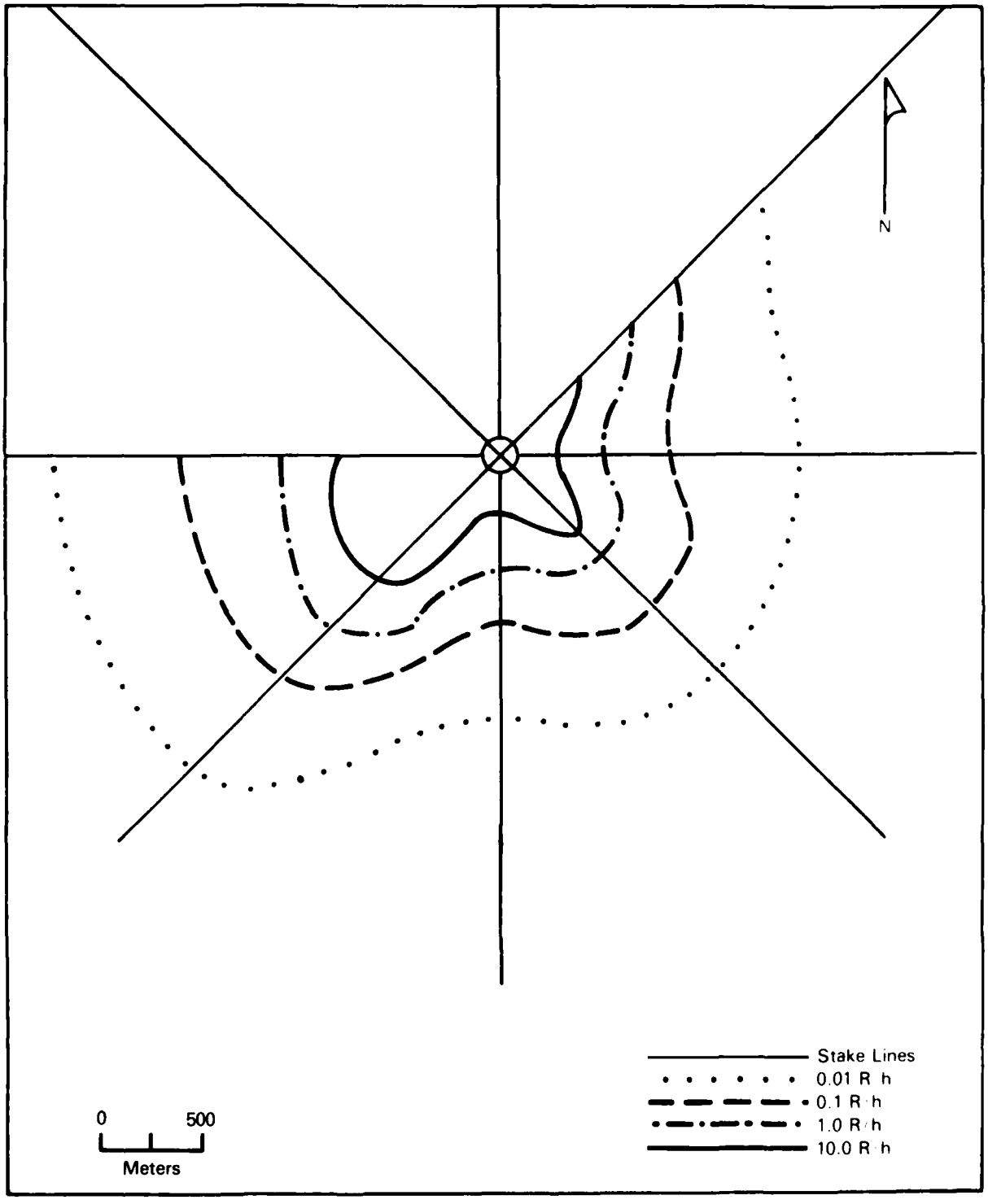
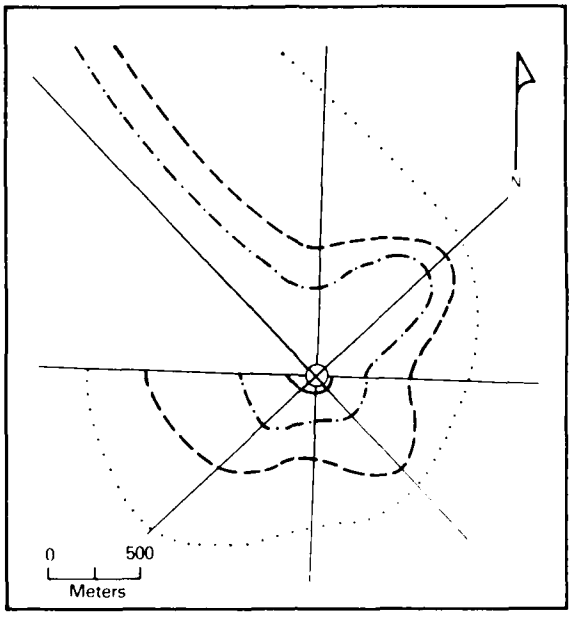
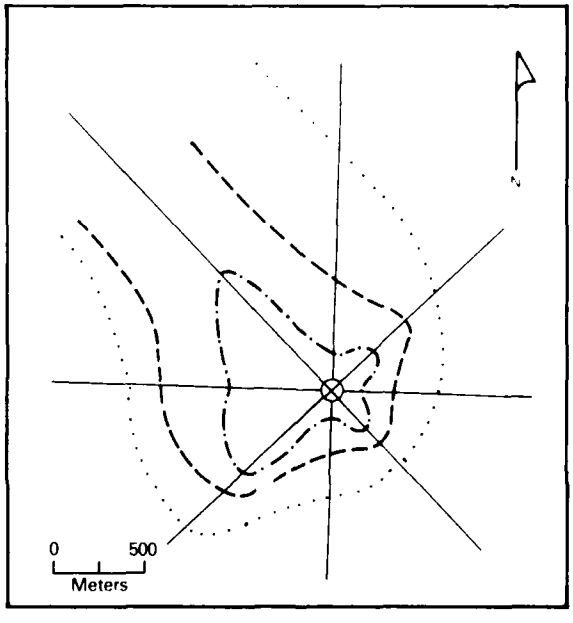


Figure 5-4: INITIAL RADIATION ISOINTENSITY MAP FOR SHOT HOW 5 JUNE 1952, 0600 HOURS



7 JUNE 1952, 0500 HOURS



9 JUNE 1952, 0500 HOURS

Stake Lines
0.01 R h
0.1 R h
1.0 R h
10.0 R h

Figure 5-5: SUBSEQUENT RADIATION ISOINTENSITY MAPS FOR SHOT HOW

SHOTS EASY THROUGH HOW
REFERENCE LIST

The following list of references represents only those documents cited in the EASY through HOW volume. When a DNA-WT document is followed by an EX, the latest version has been cited. A complete list of documents reviewed during the preparation of the TUMBLER-SNAPPER reports is contained in the Operation TUMBLER-SNAPPER volume.

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An availability statement has been included at the end of the reference citation for those readers who wish to read or obtain copies of source documents. Availability statements were correct at the time the bibliography was prepared. It is anticipated that many of the documents marked unavailable may become available during the declassification review process. The Coordination and Information Center (CIC) and the National Technical Information Service (NTIS) will be provided future DNA-WT documents bearing an EX after the report number.

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U.S. Army Nuclear & Chemical Agency
ATTN: Library

DEPARTMENT OF THE NAVY

Aviation History Unit
Department of the Navy
ATTN: Library

Bureau of Medicine and Surgery
Department of the Navy
ATTN: Asst for Med Surgery

DEPARTMENT OF THE NAVY (Continued)

James Carson Breckinridge Library
Department of the Navy
ATTN: Library Div

Marine Corps Nuclear Test Personnel Review
ATTN: Code MSRB-60

Merchant Marine Academy
ATTN: Director of Libraries

Naval Aviation School Command
ATTN: Library

Naval Hospital Corps School
ATTN: Library

Naval Ocean Systems Center
ATTN: Library

Naval Oceanographic Office
ATTN: Code 025, Historian

Naval Postgraduate School
ATTN: Code 1424, Library

Naval Research Laboratory
ATTN: Library

Naval School
Naval Construction Battalion Center
ATTN: Commanding Officer

Marine Corps Dev & Education Command
ATTN: J. Breckinridge Lib

Naval Sea Systems Command
ATTN: Nuclear Technology Div

Naval Surface Weapons Center
ATTN: Library

Naval War College
ATTN: Professor & Libraries

Naval Weapons Center
ATTN: Code 233

Naval Weapons Evaluation Facility
ATTN: Library

Navy Dept Library
ATTN: Librn

Navy Nuclear Power School
ATTN: Library

Navy Nuclear Test Personnel Review
2 cy ATTN: W. Loeffler

U.S. Naval Academy
Nimitz Library
ATTN: Documents & Reports Dept

Marine Corps Base
ATTN: Document Custodian

DEPARTMENT OF THE NAVY (Continued)

Office of the Judge Adv Gen
Department of the Navy
ATTN: Code 73

Marine Corps Historical Center
2 cy ATTN: Code HDH-2

U.S. Merchant Marine Academy
ATTN: Librn

U.S. Naval Air Station Library
Department of the Navy
ATTN: Library

DEPARTMENT OF THE AIR FORCE

Academy Library DFSELD
U.S. Air Force Academy
ATTN: Library

Aerospace Defense Command
ATTN: Historian

Air Force Communications Command
ATTN: Historian

Air Force Institute of Technology
ATTN: Library

Air Force Logistics Command
ATTN: Historian

Air Force Nuclear Test Personnel Review
ATTN: HQ USAF/SGES

Air Force School of Aerospace Medicine
ATTN: Strughold Library

Air Force Systems Command
ATTN: Historian

Air Force Technical Applications Center
ATTN: Historian

Air Force Weapons Laboratory
Air Force Systems Command
ATTN: Tech Library

Air National Guard
ATTN: Historian

Air Training Command
ATTN: Historian

Air University Library
Department of the Air Force
ATTN: AUL-LSE

Military Air Lift Command
ATTN: Historian

Commander-in-Chief
Pacific Air Forces
ATTN: Historian

Tactical Air Command
Department of the Air Force
ATTN: Historian

DEPARTMENT OF THE AIR FORCE (Continued)

Strategic Air Command
Department of the Air Force
ATTN: NRI-STINFO Library
ATTN: Historian

U.S. Air Force Occupational & Env Health Lab
ATTN: NTPR

DEPARTMENT OF ENERGY

Department of Energy
ATTN: OMA

Department of Energy
Nevada Operations Office
ATTN: Health Physics Div
2 cy ATTN: R. Nutley

Department of Energy
Human Health & Assessments Division
ATTN: EV-31

OTHER GOVERNMENT AGENCIES

Centers for Disease Control
U.S. Public Health Service
ATTN: G. Caldwell

Central Intelligence Agency
ATTN: Office of Medical Services

Department of Health & Human Svcs
ATTN: Office of General Counsel

Exec Ofc of The President
Management & Budget Off Lib
ATTN: Librn

Library of Congress
ATTN: Library Service Division
ATTN: Science & Technology Div
ATTN: Serial & Govt Publication

National Atomic Museum
ATTN: Historian

Department of Commerce
National Bureau of Standards
ATTN: Librn

Occupational Safety & Health Admin
ATTN: Library

Office of Health & Disability (ASPER)
ATTN: R. Copeland

Ofc of Workers Compensation Program
Department of Labor
ATTN: R. Larson

U.S. Coast Guard Academy Library
ATTN: Librn

U.S. House of Representatives
ATTN: Committee on Armed Svcs

OTHER GOVERNMENT AGENCIES (Continued)

U.S. House of Representatives
Committee on Interstate & Foreign Commerce
ATTN: Subcommittee on Health & Envir

U.S. Military Academy
ATTN: Director of Libraries

U.S. Senate
Committee on Armed Services
ATTN: Committee on Veterans Affairs

U.S. Senate
ATTN: Committee on Veterans Affairs

Veterans Administration-RO
Providence, RI
ATTN: Director

Veterans Administration-RO
Montgomery, AL
ATTN: Director

Veterans Administration-RO
Anchorage, AK
ATTN: Director

Veterans Administration-RO
Phoenix, AZ
ATTN: Director

Veterans Administration-RO
Little Rock, AR
ATTN: Director

Veterans Administration-RO
Los Angeles, CA
ATTN: Director

Veterans Administration-RO
San Francisco, CA
ATTN: Director

Veterans Administration-RO
Denver, CO
ATTN: Director

Veterans Administration-RO
Hartford, CT
ATTN: Director

Veterans Administration-RO
Wilmington, DE
ATTN: Director

Veterans Administration-OFC Central
Washington, D. C.
ATTN: Dept Veterans Benefit, Central Ofc
ATTN: Director
ATTN: Board of Veteran Appeal

Veterans Administration-RO
St. Petersburg, FL
ATTN: Director

Veterans Administration-RO
Atlanta, GA
ATTN: Director

OTHER GOVERNMENT AGENCIES (Continued)

Veterans Administration-RO
Honolulu, HI
ATTN: Director

Veterans Administration-RO
Chicago, IL
ATTN: Director

Veterans Administration-RO
Seattle, WA
ATTN: Director

Veterans Administration-RO
Indianapolis, IN
ATTN: Director

Veterans Administration-RO
Des Moines, IA
ATTN: Director

Veterans Administration-RO
Wichita, KS
ATTN: Director

Veterans Administration-RO
Louisville, KY
ATTN: Director

Veterans Administration-RO
New Orleans, LA
ATTN: Director

Veterans Administration-RO
Togus, ME
ATTN: Director

Veterans Administration-RO
Baltimore, MD
ATTN: Director

Veterans Administration-RO
Boston, MA
ATTN: Director

Veterans Administration-RO
St. Paul, MN
ATTN: Director

Veterans Administration-RO
Jackson, MS
ATTN: Director

Veterans Administration-RO
Huntington, WV
ATTN: Director

Veterans Administration-RO
St. Louis, MO
ATTN: Director

Veterans Administration-RO
Ft. Harrison, MT
ATTN: Director

National Archives
ATTN: Librn

OTHER GOVERNMENT AGENCIES (Continued)

Veterans Administration-RO
Lincoln, NE
ATTN: Director

Veterans Administration-RO
Reno, NV
ATTN: Director

Veterans Administration-RO
Manchester, NH
ATTN: Director

Veterans Administration-RO
Newark, NJ
ATTN: Director

Veterans Administration-RO
Milwaukee, WI
ATTN: Director

Veterans Administration-RO
Albuquerque, NM
ATTN: Director

Veterans Administration-RO
Buffalo, NY
ATTN: Director

Veterans Administration-RO
New York, NY
ATTN: Director

Veterans Administration-RO
Winston-Salem, NC
ATTN: Director

Veterans Administration-RO
Fargo, ND
ATTN: Director

Veterans Administration-RO
Cleveland, OH
ATTN: Director

Veterans Administration-RO
Muskogee, OK
ATTN: Director

Veterans Administration-RO
Portland, OR
ATTN: Director

Veterans Administration-RO
Pittsburgh, PA
ATTN: Director

Veterans Administration-RO
Philadelphia, PA
ATTN: Director

Veterans Administration-RO
San Francisco, CA
ATTN: Director

Veterans Administration-RO
San Juan, Puerto Rico
ATTN: Director

OTHER GOVERNMENT AGENCIES (Continued)

Veterans Administration-RO
Columbia, SC
ATTN: Director

Veterans Administration-RO
Sioux Falls, SD
ATTN: Director

Veterans Administration-RO
Houston, TX
ATTN: Director

Veterans Administration-RO
Waco, TX
ATTN: Director

Veterans Administration-RO
Salt Lake City, UT
ATTN: Director

Veterans Administraiton-RO
White River Junction, VT
ATTN: Director

Veterans Administration-RO
Roanoke, VA
ATTN: Director

Veterans Administration-RO
Cheyenne, WY
ATTN: Director

Veterans Administration-RO
San Diego, CA
ATTN: Director

Veterans Administration-RO
Boise, ID
ATTN: Director

Veterans Administration-RO
Detroit, MI
ATTN: Director

Veterans Administration-RO
Nashville, TN
ATTN: Director

The White House
ATTN: Domestic Policy Staff

DEPARTMENT OF ENERGY CONTRACTORS

Lawrence Livermore National Lab
ATTN: Tech Info Dept Library

Los Alamos National Lab
ATTN: Library
2 cy ATTN: ADPA MMS 195

Sandia National Lab
ATTN: W. Hereford
ATTN: Central Library

Reynolds Electrical & Engr Co., Inc
ATTN: CIC
ATTN: W. Brady

OTHER

Adams State College
ATTN: Librn

Akron Public Library
ATTN: Librn

Alabama State Dept of Archives & History
ATTN: Military Records Div

University of Alabama
ATTN: Reference Dept/Docs

University of Alaska Library at Anchorage
ATTN: Librn

University of Alaska
ATTN: Dir of Libraries

Albany Public Library
ATTN: Librn

Alexander City State Jr College
ATTN: Librn

Allegheny College
ATTN: Librn

Allen County Public Library
ATTN: Librn

Altoona Area Public Library
ATTN: Librn

American Statistics Index
Congressional Info Service, Inc
ATTN: Cathy Jarvey

Anaheim Public Library
ATTN: Librn

College of Wooster
ATTN: Gov Docs

Angelo State University Library
ATTN: Librn

Angelo Iacoboni Public Library
ATTN: Librn

Anoka County Library
ATTN. Librn

Appalachian State University
ATTN: Library Docs

Arizona State University Library
ATTN: Librn

University of Arizona
ATTN: Gov Doc Dept/C. Bower

Arkansas College Library
ATTN: Library

Brooklyn College
ATTN: Doc Div

OTHER (Continued)

Arkansas Library Comm
ATTN: Library

Arkansas State University
ATTN: Library

University of Arkansas
ATTN: Gov Docs Div

Austin College
ATTN: Librn

Atlanta Public Library
ATTN: Ivan Allen Dept

Atlanta University
ATTN: Librn

Auburn University Library at Mongomery (Reg)
ATTN: Librn

C. W. Post Ctr Long Island University
ATTN: Librn

Bangor Public Library
ATTN: Librn

Bates College Library
ATTN: Librn

Baylor University Library
ATTN: Docs Dept

Beloit College Libraries
ATTN: Serials Docs Dept

Bemidji State College
ATTN: Library

State University College
ATTN: Gov Docs

Akron University
ATTN: Gov Docs

Boston Public Library (Reg)
ATTN: Docs Dept

Bowdoin College
ATTN: Librn

Bowling Green State University
ATTN: Lib Gov Docs Services

Bradley University
ATTN: Librn

Brandeis University Library
ATTN: Docs Section

Brigham Young University
ATTN: Librn

Brigham Young University
ATTN: Docs Collection

Brookhaven National Laboratory
ATTN: Tech Library

OTHER (Continued)

Broward County Library Sys
ATTN: Librn

Brown University
ATTN: Librn

Bucknell University
ATTN: Reference Dept

Buffalo & Erie Co Public Library
ATTN: Librn

State University Library of California at Fresno
ATTN: Library

University Library of California at Los Angeles
ATTN: Pub Affairs Serv U.S. Docs

University of California at San Diego
ATTN: Docs Dept

State College Library of California at Stanislaus
ATTN: Library

California State Polytechnic University Library
ATTN: Librn

California State University at Northridge
ATTN: Gov Doc

California State Library (Reg)
ATTN: Librn

California State University at Long Beach Library
ATTN: Librn

California State University
ATTN: Librn

California State University
ATTN: Librn

California University Library
ATTN: Gov Pub Dept

California University Library
ATTN: Librn

California University Library
ATTN: Gov Docs Dept

California University Library
ATTN: Docs Sec

University of California
ATTN: Gov Docs Dept

Calvin College Library
ATTN: Librn

Kearney State College
ATTN: Gov Docs Dept

Carleton College Library
ATTN: Librn

OTHER (Continued)

Carnegie Library of Pittsburgh
ATTN: Librn

Carnegie Mellon University
ATTN: Dir of Libraries

Carson Regional Library
ATTN: Gov Pubs Unit

Case Western Reserve University
ATTN: Librn

Casper College
ATTN: Librn

University of Central Florida
ATTN: Library Docs Dept

Central Michigan University
ATTN: Library Docs Sec

Central Missouri State Univ
ATTN: Gov Docs

Central State University
ATTN: Lib Docs Dept

Central Washington University
ATTN: Lib Docs Sec

Central Wyoming College Library
ATTN: Librn

Charleston County Library
ATTN: Librn

Charlotte & Mechlenburg County Public Library
ATTN: E. Correll

Chattanooga Hamilton County, Bicentennial Library
ATTN: Librn

Chesapeake Public Library System
ATTN: Librn

Chicago Public Library
ATTN: Gov Pubs Dept

State University of Chicago
ATTN: Librn

Chicago University Library
ATTN: Dir of Libraries
ATTN: Docs Processing

Cincinnati University Library
ATTN: Librn

Claremont Colleges Libraries
ATTN: Doc Collection

Clemson University
ATTN: Dir of Libraries

OTHER (Continued)

Cleveland Public Library
ATTN: Docs Collection

Cleveland State University Library
ATTN: Librn

Coe Library
ATTN: Docs Div

Colgate University Library
ATTN: Ref Lib

Colorado State University Libraries
ATTN: Librn

University of Colorado Libraries
ATTN: Dir of Libraries

Columbia University Library
ATTN: Docs Svc Ctr

Columbus & Franklin Cty Public Library
ATTN: Gen Rec Div

Compton Library
ATTN: Librn

Connecticut State Library (Reg)
ATTN: Librn

University of Connecticut
ATTN: Gov't of Connecticut

University of Connecticut
ATTN: Dir of Libraries

Cornell University Library
ATTN: Librn

Corpus Christi State University Library
ATTN: Librn

Culver City Library
ATTN: Librn

Curry College Library
ATTN: Librn

Dallas County Public Library
ATTN: Librn

Dallas Public Library
ATTN: Librn

Dalton Junior College Library
ATTN: Librn

Dartmouth College
ATTN: Librn

Davenport Public Library
ATTN: Librn

Davidson College
ATTN: Librn

OTHER (Continued)

Dayton & Montgomery City Public Library
ATTN: Librn

University of Dayton
ATTN: Librn

Decatur Public Library
ATTN: Librn

Dekalb Community College So Cpus
ATTN: Librn

Delaware Pauw University
ATTN: Librn

University of Delaware
ATTN: Librn

Delta College Library
ATTN: Librn

Delta State University
ATTN: Librn

Denison University Library
ATTN: Librn

Denver Public Library (Reg)
ATTN: Docs Div

Dept of Library & Archives (Reg)
ATTN: Librn

Detroit Public Library
ATTN: Librn

Burlington Library
ATTN: Librn

Dickinson State College
ATTN: Librn

Alabama Agricultural Mechanical University & Coll
ATTN: Librn

Drake University
ATTN: Cowles Library

Drew University
ATTN: Librn

Duke University
ATTN: Pub Docs Dept

Duluth Public Library
ATTN: Docs Sec

East Carolina University
ATTN: Lib Docs Dept

East Central University
ATTN: Librn

East Islip Public Library
ATTN: Librn

OTHER (Continued)

East Orange Public Library
ATTN: U.S. Gov't Depository

East Tennessee State University Sherrod Library
ATTN: Docs Dept

East Texas State University
ATTN: Library

Monmouth County Library Eastern Branch
ATTN: Librn

Eastern Illinois University
ATTN: Librn

Eastern Kentucky University
ATTN: Librn

Eastern Michigan University Library
ATTN: Library

Eastern Montana College Library
ATTN: Docs Dept

Eastern New Mexico University
ATTN: Librn

Eastern Oregon College Library
ATTN: Librn

Eastern Washington University
ATTN: Librn

El Paso Public Library
ATTN: Docs & Geneology Dept

Elko County Library
ATTN: Librn

Elmira College
ATTN: Librn

Elon College Library
ATTN: Librn

Enoch Pratt Free Library
ATTN: Docs Ofc

Emory University
ATTN: Librn

Evansville & Vanderburgh Cty Public Library
ATTN: Librn

Everett Public Library
ATTN: Librn

Fairleigh Dickinson University
ATTN: Depository Dept

Florida A & M University
ATTN: Librn

Florida Atlantic University Library
ATTN: Div of Pub Docs

OTHER (Continued)

Florida Institute of Technology
ATTN: Library

Florida International University Library
ATTN: DLCS Sec

Florida State Library
ATTN: Docs Sec

Florida State University
ATTN: Librn

University of Florida
ATTN: Docs Dept

Fond Du Lac Public Library
ATTN: Librn

Ft Hays State University
Ft Hays Kansas State College
ATTN: Librn

Ft Worth Public Library
ATTN: Librn

Free Public Library of Elizabeth
ATTN: Librn

Free Public Library
ATTN: Librn

Freeport Public Library
ATTN: Librn

Fresno Cty Free Library
ATTN: Librn

Gadsden Public Library
ATTN: Librn

Garden Public Library
ATTN: Librn

Gardner Webb College
ATTN: Docs Library

Gary Public Library
ATTN: Librn

Georgetown University Library
ATTN: Gov Docs Room

Georgia Institute of Technology
ATTN: Librn

Georgia Southern College
ATTN: Librn

Georgia Southwestern College
ATTN: Dir of Libraries

Georgia State University Library
ATTN: Librn

OTHER (Continued)

University of Georgia
ATTN: Dir of Libraries (Reg)

Glassboro State College
ATTN: Librn

Gleeson Library
ATTN: Librn

Graceland College
ATTN: Librn

Grand Forks Public City-County Library
ATTN: Librn

Grand Rapids Public Library
ATTN: Dir of Lib

Greenville County Library
ATTN: Librn

Guam RFK Memorial University Library
ATTN: Fed Depository Coll

University of Guam
ATTN: Librn

Gustavus Adolphus College
ATTN: Librn

South Dakota University
ATTN: Librn

Hardin-Simmons University Library
ATTN: Librn

Hartford Public Library
ATTN: Librn

Harvard College Library
ATTN: Dir of Lib

Harvard College Library
ATTN: Serials Rec Div

University of Hawaii Library
ATTN: Gov Docs Coll

Hawaii State Library
ATTN: Fed Docs Unit

University of Hawaii at Monoa
ATTN: Dir of Libraries (Reg)

University of Hawaii
Hilo Campus Library
ATTN: Librn

Haydon Burns Library
ATTN: Librn

Hennepin County Library
ATTN: Gov Docs

Henry Ford Community College Library
ATTN: Librn

OTHER (Continued)

Herbert H. Lehman College
ATTN: Lib Docs Div

Hofstra University Library
ATTN: Docs Dept

Hollins College
ATTN: Librn

Hopkinsville Community College
ATTN: Librn

Wagner College
ATTN: Librn

University of Houston Library
ATTN: Docs Div

Houston Public Library
ATTN: Librn

Tulane University
ATTN: Docs Dept

Hoyt Public Library
ATTN: Librn

Humboldt State College Library
ATTN: Docs Dept

Huntington Park Library
ATTN: Librn

Hutchinson Public Library
ATTN: Librn

Idaho Public Library & Information Center
ATTN: Librn

Idaho State Library
ATTN: Librn

Idaho State University Library
ATTN: Docs Dept

University of Idaho
ATTN: Dir of Libraries (Reg)
ATTN: Docs Sec

University of Illinois Library
ATTN: Docs Sec

Illinois State Library (Reg)
ATTN: Gov Docs Br

Illinois University at Urbana-Champaign
ATTN: P. Watson Docs Lib

Illinois Valley Community College
ATTN: Library

Illinois State University
ATTN: Librn

Indiana State Library (Reg)
ATTN: Serial Sec

Indiana State University
ATTN: Docs Library

OTHER (Continued)

Indiana University Library
ATTN: Docs Dept

Indianapolis Marion County Public Library
ATTN: Social Science Div

Iowa State University Library
ATTN: Gov Docs Dept

Iowa University Library
ATTN: Gov Docs Dept

Butler University
ATTN: Librn

Isaac Delchdo College
ATTN: Librn

James Madison University
ATTN: Librn

Jefferson County Public Library
Lakewood Regional Library
ATTN: Librn

Jersey City State College
ATTN: F. A. Irwin Library Periodicals
Doc Sec

Johns Hopkins University
ATTN: Docs Library

La Roche College
ATTN: Librn

Johnson Free Public Library
ATTN: Librn

Kalamazoo Public Library
ATTN: Librn

Kansas City Public Library
ATTN: Docs Div

Kansas State Library
ATTN: Librn

Kansas State University Library
ATTN: Docs Dept

University of Kansas
ATTN: Dir of Library (Reg)

University of Texas
ATTN: Lyndon B. Johnson School of Public
Affairs Library

Maine Maritime Academy
ATTN: Librn

University of Maine
ATTN: Librn

OTHER (Continued)

Kent State University Library
ATTN: Docs Div

Kentucky Dept of Library & Archives
ATTN: Docs Sec

University of Kentucky
ATTN: Gov Pub Dept
ATTN: Dir of Lib (Reg)

Kenyon College Library
ATTN: Librn

Lake Forest College
ATTN: Librn

Lake Sumter Community College Library
ATTN: Librn

Lakeland Public Library
ATTN: Librn

Lancaster Regional Library
ATTN: Librn

Lawrence University
ATTN: Docs Dept

Brigham Young University
ATTN: Docs & Map Sec

Library and Statutory Dist & Svc
2 cy ATTN: Librn

Earlham College
ATTN: Librn

Little Rock Public Library
ATTN: Librn

Long Beach Public Library
ATTN: Librn

Los Angeles Public Library
ATTN: Serials Div U.S. Docs

Louisiana State University
ATTN: Gov Doc Dept
ATTN: Dir of Libraries (Reg)

Louisville Free Public Library
ATTN: Librn

Louisville University Library
ATTN: Librn

Hoover Institution
ATTN: J. Bingham

OTHER (Continued)

Manchester City Library
ATTN: Librn

Mankato State College
ATTN: Gov Pubs

University of Maine at Farmington
ATTN: Dir of Libraries

Marathon County Public Library
ATTN: Librn

Principia College
ATTN: Librn

University of Maryland
ATTN: McKeldin Library Docs Div

University of Maryland
ATTN: Librn

University of Massachusetts
ATTN: Gov Docs Coll

Maui Public Library
Kahului Branch
ATTN: Librn

McNeese State University
ATTN: Librn

Memphis & Shelby County Public Library & Information Center
ATTN: Librn

Memphis State University
ATTN: Librn

Mercer University
ATTN: Librn

Mesa County Public Library
ATTN: Librn

Miami Dade Community College
ATTN: Librn

University of Miami Library
ATTN: Gov Pubs

Miami Public Library
ATTN: Docs Div

Miami University Library
ATTN: Docs Dept

University of Santa Clara
ATTN: Docs Div

Michigan State Library
ATTN: Librn

Michigan State University Library
ATTN: Librn

Murray State University Library
ATTN; Lib

OTHER (Continued)

Michigan Tech University
ATTN: Lib Docs Dept

University of Michigan
ATTN: Acq Sec Docs Unit

Middlebury College Library
ATTN: Librn

Millersville State College
ATTN: Librn

State University of New York
ATTN: Docs Librn

Milwaukee Public Library
ATTN: Librn

Minneapolis Public Library
ATTN: Librn

University of Minnesota
ATTN: Dir of Libraries (Reg)

Minot State College
ATTN: Librn

Mississippi State University
ATTN: Librn

University of Mississippi
ATTN: Dir of Libraries

Missouri University at Kansas City General
ATTN: Librn

University of Missouri Library
ATTN: Gov Docs

M.I.T. Libraries
ATTN: Librn

Mobile Public Library
ATTN: Gov Info Div

Midwestern University
ATTN: Librn

Montana State Library
ATTN: Librn

Montana State University Library
ATTN: Librn

University of Montana
ATTN: Dir of Libraries (Reg)

Montebello Library
ATTN: Librn

Moorhead State College
ATTN: Library

Mt Prospect Public Library
ATTN: Gov't Info Ctr

OTHER (Continued)

Nassau Library System
ATTN: Librn

Natrona County Public Library
ATTN: Librn

Nebraska Library Community
Nebraska Public Clearinghouse
ATTN: Librn

University of Nebraska at Omaha
ATTN: Univ Lib Docs

Nebraska Western College Library
ATTN: Librn

Universi'y of Nebraska
ATTN: Dir of Libraries (Reg)

University of Nebraska Library
ATTN: Acquisitions Dept

University of Nevada Library
ATTN: Gov Pubs Dept

University of Nevada at Las Vegas
ATTN: Dir of Libraries

New Hampshire University Library
ATTN: Librn

New Hanover County Public Library
ATTN: Librn

New Mexico State Library
ATTN: Librn

New Mexico State University
ATTN: Lib Docs Div

University of New Mexico
ATTN: Dir of Libraries (Reg)

University of New Orleans Library
ATTN: Gov Docs Div

New Orleans Public Library
ATTN: Librn

New York Public Library
ATTN: Librn

New York State Library
ATTN: Docs Control Cultural Ed Ctr

State University of New York at Stony Brook
ATTN: Main Lib Docs Sec

State University of New York Col Memorial Lib
at Cortland
ATTN: Librn

State University of New York
ATTN: Lib Docs Sec

North Texas State University Library
ATTN: Librn

OTHER (Continued)

State University of New York
ATTN: Librn

New York State University
ATTN: Docs Ctr

State University of New York
ATTN: Docs Dept

New York University Library
ATTN: Docs Dept

Newark Free Library
ATTN: Librn

Newark Public Library
ATTN: Librn

Niagara Falls Public Library
ATTN: Librn

Nicholls State University Library
ATTN: Docs Div

Nieves M. Flores Memorial Library
ATTN: Librn

Norfolk Public Library
ATTN: R. Parker

North Carolina Agricultural & Tech State
University
ATTN: Librn

University of North Carolina at Charlotte
ATTN: Atkins Lib Doc Dept

University Library of North Carolina at Greensboro
ATTN: Librn

University of North Carolina at Wilmington
ATTN: Librn

North Carolina Central University
ATTN: Librn

North Carolina State University
ATTN: Librn

University of North Carolina
ATTN: BA SS Div Docs

North Dakota State University Library
ATTN: Docs Librn

University of North Dakota
ATTN: Librn

North Georgia College
ATTN: Librn

Minnesota Div of Emergency Svcs
ATTN: Librn

OTHER (Continued)

Northeast Missouri State University
ATTN: Librn

Northeastern Oklahoma State University
ATTN: Librn

Northeastern University
ATTN: Dodge Library

Northern Arizona University Library
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Louisiana Tech University
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Auburn University
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Augusta College
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Southern Connecticut State College
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University of Southern Mississippi
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Southwestern University
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Springfield City Library
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St Louis Public Library
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Valencia Library
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Wayne State University Law Library
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West Virginia College of Grad Studies Library
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University of West Virginia
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Westerly Public Library
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Western Carolina University
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Western Illinois University Library
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Western Washington University
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Western Wyoming Community College Library
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Westmoreland City Community College
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Emporia Kansas State College
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William College Library
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Willimantic Public Library
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University of Wisconsin at Whitewater
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University of Wisconsin at Milwaukee
ATTN: Lib Docs

University of Wisconsin at Oshkosh
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University of Wisconsin at Platteville
ATTN: Doc Unit Lib

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University of Wisconsin
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University of Wisconsin
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Wyoming State Library
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University of Wyoming
ATTN: Docs Div

Yale University
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